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IN ALL THEIR DEPARTMENTS.

BY A COMMITTEE OF PRACTICAL SURVEYORS, ENGINEERS, AND ARCHITECTS, OF MUCH EXPERIENCE AND IN ACTIVE EMPLOYMENT.

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ELEMENTARY LESSONS

IN THE THREE PROFESSIONS, OR ANY OF THEM.

NO. III.—NUMBERS. NO. 3.

Roots and Powers—Exponential Numbers.—Logarithms.

WE shall endeavour to close our remarks on the properties and uses of Numbers in the present paper; and some of our young readers may perhaps think that we have dwelt too long upon a subject so elementary: we would, however, entreat of such to bear in mind, that it is by hurrying over the elementary parts, without taking the trouble to understand them, that all education is spoiled. The fabric of knowledge, like other fabrics, depends greatly upon the foundation on which it is placed, and if that foundation is an unstable one, the whole structure must be frail and tottering.

The portion of the science of Numbers at which we have arrived, is by much the most important one to Surveyors, Engineers, and Architects. It is one in fact, which is absolutely essential to the right performance of their duties; and if they understand it not, they must either be constantly dependent on those who do understand it, or they must be frequently in error without knowing, or without being aware that they are so.

What renders this department of Arithmetic so much more important to the Professions than any of the rest, is the fact of its being the connection between Arithmetic, and Magnitude or extension in space; for, if this connexion did not exist, or were not known, the measurements of the professional man would be of no use to him, as he could apply them to no practical purpose. His speculations with regard to the extent and form of any solid or piece of matter, or, which is the same thing, of the space which that piece of matter fills, might be perfectly true, and the truth might be demonstrated on geometrical grounds. But if he could not apply numbers to his measurements, and obtain results by arithmetical calculation, his geometry, however accurate and extended it might be as such, would be of no more practical use than if the things of which he spoke had no real existence.

In the application of Arithmetic to Geometry, that is, of numbers to express quantities, there are three different kinds or classes, independently altogether of the extent and form of the particular magnitudes.

A Point is the simplest of all geometrical considerations, but a point is not a magnitude,—it is merely a position in space; and all points are of equal magnitude, that is, the magnitude of any one, or any number of them, is always the same, being equal to 0: therefore, points have no arithmetical value, and cannot in any way be made the subject of any arithmetical operations; consequently, they are passed over in that part of arithmetic which connects Geometry with calculation.

The simplest of all geometrical magnitudes is a Straight Line, and as two straight lines may be equal in length, or the one of them may be longer or shorter than the other, they of course admit of measurement, and expression by numbers.

The measuring of a straight line, or the shortest distance between two points,—which is exactly the same thing, is in principle a very simple matter, though in practice it is very difficult. We have only to apply a foot rule, a measuring tape, a chain, or any other measuring instrument to it, and count the number of divisions of that measure to which it extends, and the result is the arithmetical measure of its lengths, in inches, feet, links, yards, chains, or whatever else may be the denomination of the measure applied. This, it will be observed, is a very simple operation, nothing but the mere applying of one line to another, without any thing that can be called a process; and therefore, the number expressing the length of a line is to be considered merely as a simple number, and not as the result of any arithmetical operation, whatever may be the number, or denomination of that number itself. From this simplicity of numbers expressing the length of straight lines, they are called *roots*, that is, the foundations of certain more complicated numbers, which are the results of operations. The simplest of these, taken in a geometrical point of view, or as a magnitude, is a Plane, or perfectly flat surface, of which the four sides, and also the four corners or angles, are all equal to each other. This simplest of all possible surfaces is called a square, and it is the square of any one of the sides, for they are all equal. The numerical value of a square cannot be, like that of a straight line, obtained by mere measuring, but requires an arithmetical process.

There is but one way of measuring the straight line; but if we wish to measure a surface, of which a square is the simplest example, we must measure both the length and the breadth—though in the case of the square this is not necessary, as they are equal to each other. Where the breadth has to be measured, it bears a certain relation of position to the length,—that is, it must be at right angles to it, or slope neither the one way nor the other, for if it slopes it will be greater than the true breadth. The length and breadth must express those of the surface throughout, and not at any particular part; and when they do this, and are accurately measured with the same measuring instrument, their product is the measure of the surface in terms of the square of this instrument. In the case of the square itself, the product of any side multiplied by itself is the content, area, or surface of the square, in squares of that denomination in which the side is measured. For this reason, the area of a square is called the square, or the second power of the side considered as a first power or root; and this is the simplest case of the application of arithmetic to geometry, or of finding the value of a magnitude by measurement and calculation jointly. The student should therefore thoroughly understand it, and then the more difficult cases will seem quite easy to him.

It must be understood, however, that the number obtained by multiplying the side of a square by itself, or the length of any surface by the breadth, is not of the same kind with the number expressing the lineal dimension, even though both may be called by the same name.

41. 7. 14. 120.

Thus, for instance, if the lineal dimensions are taken in inches, the content or area will be square inches. But these two descriptions of inches are not quantities of the same kind; and no multiplication, division, or any other merely arithmetical process can express the one in terms of the other. Either of them may be added to or subtracted from another number of the same kind; but the two can neither be added nor subtracted: Thus two square inches and three square inches make five square inches, but two square inches and three inches of lineal measure do not make a whole that has any meaning, and the same holds in the case of differences.

In a merely arithmetical point of view, and without reference to any relation which is not strictly arithmetical, no measure or other real quantity can be either a multiplier or a divisor in such a manner as that, in common arithmetic, the product and quotient shall be of the same kind with the multiplicand and dividend. There are certain cases however, in which measures or other real quantities—or rather the numbers expressing them, may be either factors in multiplication or terms in division. Thus, for instance, if one factor expresses a quantity, and the other factor the price or value of any unit of that quantity, the value of the whole quantity may be found by multiplication: and whatever result is found by multiplication, may be decomposed by division, and either of the two factors found by dividing by the other. These are not however the applications of arithmetic which most strictly belong to engineering, but still it is necessary that the young Engineer should understand them properly.

In the connection between magnitude and number, and the expression of the one in terms of the other, there is another relation and another measure that may be taken and introduced as a factor. We have already mentioned that a straight line is measured in one direction only, and therefore it is expressed by a root or simple number; and that a surface has extension in length and breadth at right angles to each other, and therefore it is expressible by a product in all cases, and by the second power of the side, or the product of that by itself, in the case of a square.

But the quantity may also have thickness, and be a Solid; and this thickness, though in itself it is a lineal measure, as well as the length and breadth, must stand in the same relation to each of them, that is, it must not incline more to the one than to the other, and its inclination to each must be the same both ways. This is merely saying in other words, that, just as the length and breadth are at right angles to each other, the thickness must be at right angles to them both. If this is the case, and if the lines are correctly measured, the product of the length, breadth, and thickness, which of course requires two multiplications, will express the solid contents. If the three dimensions are all equal, the solid will be a cube, or the third power of any of the edges, that is, of the length, the breadth, or the thickness, which, in a cube, are all equal to each other; and whatever may be the differences of the length, breadth, and thickness, if they are properly measured, and of the same denomination, the product of the three taken in any order that may be most convenient, will be the solidity in cubes, of which the measuring denomination is any of the edges.

These give us a third kind of numbers, as expressing the value of magnitude,—mere extension, surface, and solidity; and though the second and third are founded on the first, no two of them are commensurable with each other, or admit of rational comparison; —no length of mere lines will form even the smallest surface, and no extent of mere surfaces will form the smallest solid. It is true that we find a surface by multiplying the length by the breadth; but the breadth in this case is not a mere number, or a measure expressed by a number; for it must have a certain relation of position to the length, namely, at right angles to it. So also, we get the solidity by multiplying the product of the length and breadth by the thickness, but this multiplier is not a simple number, it is a line whose position is at right angles, both to the length and the breadth.

From these observations it will be seen that, in as far as the first three powers, number and magnitude go together. The simple number and the simple extension in one direction are both first powers, formed by no multiplication whatever. And it is for this reason that they are called the roots of the other powers. The product of any factor once by itself gives us the second power, to which we give the name of the square, and we are correct in so doing in the case of lines; but in that of mere numbers "square" has no meaning. So also the product of the same factor twice by itself is the third power; and as applied to lines it is the cube. Geometry or magnitude, in the elementary views of it, goes no farther than this; because no magnitude, or portion of matter or space, can be more than solid; but in the case of numbers we can extend the powers upward by multiplication, or downward by division, as far as ever we please.

In order to illustrate this, let us take any number we please—say, for instance, the number 10, and express several powers of it both upward and downward.

The upward powers are obtained by continual multiplication by 10, and are in fact the same as the places in the arithmetical scale of a whole number; and the downward powers are found by dividing by 10, and they are the same as the decimal places. The following arrangement will suit our purpose:

$$10000^{4},\ 1000^{3},\ 100^{2},\ 10^{1},\ 1^{0},\ \cdot1^{\frac{1}{1}},\ \cdot01^{\frac{1}{2}},\ \cdot001^{\frac{1}{3}},\ \cdot0001^{\frac{1}{4}},$$

The small figures which are placed over the right of the powers of 10, are the indices, or exponents of those powers, that is, they show the number of times that 10 is used as a factor, which is always 1 more than the number of multiplications; and the relation would be the same if any other number whatsoever were used in place of 10.

10 itself is the first of the ascending powers; and because 10 requires no multiplication in order to produce 10, the exponent of this is 1. One multiplication by 10 gives the exponent 2, and so on in the ascending powers toward your left-hand.

Then, go back to 10, or exponent 1, and examine the numbers and their exponents to your right of it. The first is 1, and the exponent is 0, which shows that 10 is not used as factor, but as a divisor, in order to find the 1. The second is, ·1 or one-tenth, which has for its exponent $\frac{1}{1}$, showing that 10 is divided twice by 10, in order to obtain ·1. The other numbers to your right of this are the results of successive divisions by 10, and of course each of them has an 0 more after the decimal point than the one preceding it, and the denominator of the exponential fraction is increased by one at every step. This scale may be carried as far as one pleases both ways; but beyond five or six 0s, it will be of small practical use.

The whole numbers to your left of 1^0, have their exponents the numbers 1, 2, 3, 4, &c.; and the fractions to your right of 1^0, have their denominators the same numbers. But these exponential

numbers, whether written as simple numbers, or as the denominators of fractions, are not to be confounded with common numbers, from which they are quite different in their nature. The exponents of the ascending powers to your left of 1^0 denote not numbers of things, but the number of times that the root, =10 in the present example, is used as a factor. So also, in the descending to your right of 1^0, the denominators of the fractional exponents, show how often the root is used as a divisor.

If we take the whole series in the direction from your left to your right, there is a successive multiplication by 10 at every step we advance; and this multiplication by 10 is indicated by 1 added to the exponent. If you consider them the other way from your left to your right, there is a division by 10 at every step, and this is indicated in the exponent by subtracting 1. Therefore the addition of exponential numbers is the same as the multiplication of those common numbers, of which they are the exponents; and the subtracting of one exponent from another, is the same as dividing the natural number answering to the exponent from which we subtract, by the natural number answering to the exponent which we subtract from it: Hence,—

If we had a series of exponential numbers, answering to the whole of the natural numbers, in the same manner as the above expression answers to 10, 100, &c., we should be enabled to get rid of the operations of multiplying and dividing, by substituting for them the simpler operations of adding and subtracting. Of course, however, we could neither add nor subtract by means of those exponential numbers. A series of numbers of this kind has been calculated, to as great an extent as is necessary in ordinary operations, and the table containing this series is called a table of THE LOGARITHMS OF NUMBERS.

The series inserted in these tables does not express the numbers themselves, but merely, as the name implies, "the voices" of numbers, that is, their values when expressed as powers of the numbers 10.

It will be observed, that 1 has 0 for its exponent, so that 1 is of no use in Logarithms, as we might at once see from the fact of its being neither a multiplier nor a divisor.

In the natural order of the numbers, there are no complete powers of 10, excepting those that consist of 1 with 0s; and as these form but a very small fraction of the whole, the chief part of the logarithms are irrational, and their values can only be approximated. At the beginning of the natural series, there are only eight numbers that have logarithms before we come to 1 as an exponent; and those eight consist wholly of decimals. Before 10 there are many more numbers, than between 0 and 1; and the logarithms of these consist of 1, with decimals. As we go on, the number in the interval between the powers of 10 increases tenfold at every step, while the logarithmic difference continues to be 1. Therefore, as we advance to higher numbers, the differences of the higher numbers gradually diminish, and are small indeed, when very high numbers are interposed between the powers of 10. Therefore, in the widening of the intervals, and the diminishing of the differences between numbers equidistant from each other, Logarithms follow a very peculiar law, and the logarithms of prime numbers could not be traced, except by a process too difficult for ordinary calculation. But they have been calculated to as many places of figures as gives an approximation sufficiently near for practical purposes, and thus we have all the advantage without any of the labour.

The logarithms of numbers are most conveniently used along with those of the lines in and about a circle answering to angular measurements, and these are inserted in the tables, and wonderfully simplify the business of calculation, which is thus rendered a mechanical operation of a very short and easy kind.

As, from their very nature, Logarithms reduce multiplication to addition, and division to subtraction, it follows almost as a matter of course, that the finding of powers should be reduced to multiplying the logarithms by the exponents, and the finding of roots to division by the same. This is another very great advantage; and were it possible to add and subtract by means of Logarithms, they would furnish us with as short, simple, and complete a system of Arithmetic as any one could possibly desire. As it is, they constitute one of the greatest improvements that ever was made; and, taken in conjunction with Decimal Arithmetic, there is nothing that has tended so much to the improvement of calculation, and of all those sciences which are founded upon calculation.

As the logarithm of 1 is 0, of 10, 1, of 100, 2, of 1000, 3, and so on, the logarithms of all the numbers intermediate between these must be made up of decimals as well as of integers. Thus from 10 to 100, these must be 1 with decimal places; from 100 to 1000, they must be 2 with decimal places; and so on, always adding another 1 to the integral part of the logarithm, as the power of 10 is increased tenfold by annexing an additional 0. These integral parts of the logarithms are called the indexes to them; and the index to a logarithm is always the same for the same number of integral places in the number, by what figures soever these places may be occupied. Hence, before taking the decimal parts of the logarithms out of the tables, it is usual to write down all the indexes, and place decimal points after them. If there are integers in the number, no indication of the fact is required; but if there are no integers, the index, or integral part of the logarithm, must have a sign expressive of the distance to the right of the decimal point at which it begins. This is the same as the denominator of the fractional exponent; and as a denominator, being a divisor in common arithmetic, becomes a subtractive number in a logarithm, the usual mark for it is the sign — *minus*, either before it or over it. The young student of Logarithms must however take care, and not overstretch the extent of this sign. It applies only to the index, and not to the decimal part of the logarithm; and thus when the logarithm as a whole has to be added, the negative index must be subtracted; and when the logarithm has to be subtracted, the negative index must be added.

We have now endeavoured to explain the nature of powers, roots, exponents, and logarithms, in the most simple manner, and with the least possible technicality; and we shall close this paper with a very brief recapitulation:—

1.—A Power of a number is the product arising from the multiplication of that number any number of times by itself; and the number of the power is the times that the number is used as a factor, which is always one greater than the number of multiplications.

It is this number of the power which is the Exponent.

If the root is greater than 1, the powers increase in value as the exponents increase; but if the root is less than 1, the greater the exponent, the less the value of the power. This is evident from the fact that, as, at each multiplication, the multiplier is less than 1, the product must be less than the multiplicand. Thus, if the original number is $\frac{1}{2}$, the powers will be $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{12}$, and

so on, every one half the value of the one immediately preceding it, just if there were a division by 2.

From the nature of a power, it follows, that INVOLUTION, or the finding of any power of a given root, or number considered as a root, is nothing more than multiplying as often as the exponent requires. If the root or given number be all integers, the power will also be all integers; but if there are decimals in the root, there must be as many decimal places in the power as the number of those in the root multiplied by the exponent.

2. Any number may be given as a power, and the question may be to find the root of it, answering to any given exponent. The only exception to this is the number 1, of which all roots and all powers are 1—1 being neither a multiplier nor a divisor.

The finding of a root, or the *Evolution* of it as it is termed, is a species of division, but it differs from common division in this, that, instead of the divisor being given, it is the number sought; and it has to be obtained by the performance of as many successive divisions as the number of the exponent diminished by 1. This cannot of course be done upon the common principles, and by the ordinary rules of Arithmetic; because, in arithmetical division, the divisor must be given as well as the dividend, and the resulting quotient is not equal to the divisor, nor has it any necessary relation to it.

Before, therefore, we can find the simplest root, we must have recourse to new methods, which may be explained either upon geometrical or arithmetical methods. The only roots of which the finding is of much use in practice, are the square root and the cube root; and though it is easy enough to investigate rules, or formulæ, for finding any roots whatsoever, yet, if the exponents are high, these operations are more laborious than useful.

In finding a root in any other way than by trial and error, which is very tedious, as well as very clumsy, we cannot easily, if the root consists of more than a single figure, find it all at once; but we must first find the left-hand figure, then the next to that, and so on, till the whole operation is performed.

A geometrical explanation of this, for the square root and the cube root, is given in page 177 of the first volume of the "Surveyor, Engineer, and Architect." If the eight solids which are there represented as detached from each other are brought close together, it will be seen that they will make a perfect cube, only they are shown in perspective and not geometrically. If they are thus brought together, and any one of the six faces of the cube is examined, that face will represent the composition of the square of the whole of a line, in terms of any two parts into which that line may be divided; and this composition is made up of the following four portions:—

1. The square of the first part;

2 and 3. Twice the product of the first and second parts; and,

4. The square of the second part.

When considered numerically—and any line whatsoever may be considered in this way,—this truth is usually expressed by these words, which are simple and easily remembered:—The square of the sum of two numbers is equal to the sum of their squares, and twice their product. The same truth may be stated and explained arithmetically, without any reference to a geometrical dissection. Thus, if the length of any line is 6 feet 3 inches, the square of that line will consist of,—1. the square of 6 feet;

2 & 3. Twice the product of 6 feet by 3 inches; and, 4. The square of 3 inches.

This follows from the very obvious principle, that, in order to multiply the whole of a number, or line represented by a number, by another number or line represented by a number, we must multiply all the parts of the one by all the parts of the other, it being a matter of perfect indifference which of them was used as multiplicand, and which as multiplier. In the case of a square, the multiplier and multiplicand are of course the same.

Then in our example, we have first to multiply 6 feet 3 inches, by 6 feet; next to multiply 6 feet 3 inches by 3 inches; and it will at once be seen, that the product consists of the square of 6 feet, and 6 feet multiplied by 3 inches, in the first step; and the square of 3 inches, together with 6 feet multiplied by 3 inches; and these portions of the product are the squares of the two parts of the line or number, and twice the product of the same two parts. The square of 6 feet is 36 square feet; the square of 3 inches is 9 square inches; and twice the product of 6 feet and 3 inches, consists of two oblongs, each 6 feet long and 3 inches broad.

Besides the use of this, in understanding the method of finding the square root, it is of great value in finding the contents of squares and rectangles, when the dimensions are taken in several denominations. Thus, if we collect the particulars of the above we have, first, 36 square feet; secondly, two pieces 6 feet long, and 3 inches broad, which make 3 feet square, or 39 square feet; and thirdly, we have 9 square inches, which are equal to $\frac{1}{16}$th of a foot; so that $39\frac{1}{16}$ square feet is the area or surface of the square.

The composition and analysis of a cube, as consisting of more parts, are more complicated than those of a square; but they depend upon the same principles, and are equally easy to understand after we have studied them a little. Upon looking back at the figure on page 177, to which we have already alluded, it will be found to consist of eight solids. I, VIII are cubes, the first the cube of *a*, the larger part of the line, and the second the cube of *b*, the smaller portion of the same.

II, III, IV, are squares of the larger dimensions in the one way, and as thick as the smaller dimensions in the other. V, VI, and VII (of which the engraver has not marked VI), are squares of the smaller portion of the line in one direction, and as long as the larger portion in the other. These eight solids, if brought close together, would compose the entire cube, any face of which is divided in the same manner as the square, to which we formerly alluded. It is usual to cite the composition of a cube, briefly, in these words: "The cube of the sum of two numbers, or two lines represented by numbers, is equal to or made up of the sum of the cubes of the parts, and three times the square of each part multiplied by the other part."

A number may be separated into any two parts, which together make up the whole of that number, and any two figures of a number that consists of several figures, may be considered as standing to each other in the relation of tens for the left-hand one, and units for the right-hand. When we consider a number in this way, the units, that is, what are considered as units, must be always restricted to a single figure, whether that be the real unit's place of the number, or any higher place. But there is no such restriction with regard to the tens, for any number of figures stand in the relation of tens to the figures on the right of them, considered as units. Take, for example, the numbers 7, 8, 5, 4; and it is actually 785 tens and 4 units. Disregard one figure on the right, and the remaining figures answer to 78 tens and 5 units. Disregard two figures on the right, and the remaining figures stand in the relation of 7 tens and 8 units;—and whatever may be the number

of figures, or their individual values, every number may be treated in this way.

This is simply an application of the scale of numbers, and it is of great use to us in the finding of roots, where the root is to consist of more figures than one. If the root is to consist of only one figure, the arithmetical scale gives us no assistance; and the particular figure forming the root must be found by trial. There cannot be more than nine trials required for this, and in the case of the square root, the squares of the figures are in the common tables of multiplication. They are from 1 to 9 inclusive; and their values are as follow: 1, 4, 9, 16, 25, 36, 49, 64, and 81.

The cubes are of course not found in the common table of multiplication, because that table consists of single multiplications, or of the products of only two factors; but if we multiply the above numbers by the figures from 1 to 9 inclusive, we obtain the cubes of the first nine numbers, and it is of advantage to commit these to memory. They are, 1, 8, 27, 64, 125, 216, 343, 512, and 729.

On examining these, we find that the number of figures, in the case of a single figure, does not exceed the exponent of the power,—does not exceed two figures in the case of the square, or three in that of the cube, as there cannot be a greater power of a single figure than the power of nine.

When any figure or figures are considered as being tens, an 0 must be understood on the right of them; and in any power of a number thus considered, there must be as many 0s as the exponent or number of the power. In the case of a square, there will be two 0s, in the case of a cube three, and so on, the number of 0s always answering to the exponent. If a figure or figures were considered as hundreds, there would be two 0s on the right, and consequently any power would contain twice as many 0s as the number of the exponent; if considered as thousands, there would be three 0s on the right of each factor, and three times as many in a power as the number of the exponent; and so on, for every increase of 1 in the exponent, there would be an increase in the power of as many 0s as there were on the right of the factor or root. It is not, however, necessary to go much into these last named matters, for the relations of tens and units are quite sufficient for practical purposes; and it is this which makes the finding of roots a simple, though, in the case of high exponents, rather a laborious matter.

Supposing the number of which the square root were sought to be 56, there would be only one integral figure in that root, because there are but two figures in the power, and the square of ten, the smallest number that can be expressed in two figures, consists of three. The performance of the operation we must reserve for a very short article in some subsequent number, and therefore we shall merely give the briefest possible abstract of what has to be done in the arithmetic of powers and roots.

In this there are three leading problems:—1. To find any power of any given number; and this is merely multiplication of the number by itself, till the multipliers and the original multiplicand count as many as the exponent.

2. To find any root of any number. This is a case of division, certainly, but, as already noticed, only the dividend is given, and the divisor, with certain expressed conditions, is the quantity sought.

3. To find what power any one given number is of any other given number. This seems also analogous to a case of division; but it is not one in reality; for the two numbers given are common numbers, and the number sought is exponential, or expresses a number of times. This number of times may be anything,—a whole number without decimals or with decimals, or a decimal number altogether; and if it be decimal, it never can terminate or circulate, and consequently, it cannot be expressed exactly, though it may be so near enough for all practical purposes. The solution of this problem, though it is strictly a numerical problem, does not fall within the limits of common arithmetic. It is the problem, analogous to the construction of a table of common logarithms of numbers, in which the series of natural numbers is expressed by the powers that the individual numbers are of 10,—or in other words, the logarithms are the exponents of those powers. It is not very essential, that the young Surveyor, Engineer or Architect should be familiar with such a problem as this: but it were as well that he knew something of it, for there is much knowledge to be gleaned by the way. We may have a future opportunity of at least attempting to explain it in common language, which is by no means an easy matter.

ON THE OBSTACLES WHICH IMPEDE THE PROGRESS OF THE ENGINEERING ARTS IN ENGLAND.

In our number for May, we pointed out the loss which these arts sustain, from the position of the sovereign being such as precludes the effective patronizing of them—or of any thing else; and from the influence which this must have on that branch of society which is understood to be most about court, and pronest to ape the sovereign, whether for good or for evil. What we then stated, we believe, or rather know from the evidence, to be perfectly true, and indeed a state of things that could not well be otherwise, inasmuch as the general cause to which it is owing is too powerful for being counteracted by the personal disposion of even a monarch. It is owing to this, and to this alone, that our most gracious sovereign pays far more attention to the new dog kennel which is constructing for the accommodation of her royal consort's favourite puppies, than to all the historical interest and the architectural grandeur of the majestic palace at Windsor.

Though this is unquestionably true, we must not blame our gracious sovereign for it: for the fault lies not there, but in the system of the country; and it is so entwined round what were of old the only influential classes, that they appear unable as well as unwilling to extricate themselves from its entanglement. Nor does it exercise its baneful influence upon the full-grown and grey-bearded men of rank only, for it fastens upon them almost the instant they quit the cradle, entwines them at school and college, and so onward to their graves. If the sovereign and government of Britain had the same power and the same applause as those of other countries, they would do the same acts of utility and magnificence; but they are tied down by a greater tyranny than that of other kings, so that whatever may be their talents or their desires, they have no scope for the exercise and the gratification of them; therefore they are compelled to have recourse to comparatively frivolous pursuits in order to save themselves from ennui, the great dragon, which devours more of the energies of human nature than any other that could be named. While the Roman senate preserved their dignity and independence, their debates were manly, and their decisions useful; and it was not till luxury had enervated them, and the army and those whom the army

had set up, reduced them to a perfect nonentity, that the tyrant issued his command to them gravely to debate, and rightly to determine, what was "the best sauce for a turbot;" and in England, in which the tree of the knowledge, *of law*, seems to thrive better than any where else, if the sovereign is legally tied up from doing any thing great, the sovereign is not to be blamed for it: we should find out where the blame really ought to rest, and lay it there.

Now, there is something in the modes of thinking, confirmed by long habit among the landed proprietors, which prevents them from encouraging improvements and public works, and makes them labour with all their might in order to restrain that knowledge and enterprize, in which alone such improvements and works should originate. In this, they are powerfully assisted by the Established Church, whose object as a church appears to be to keep down inquiry and knowledge. We do not mean to say that there are not, in both classes, many exceptions to this; and as little do we mean to say that those who belong to either the one class or the other, are naturally, knowingly, and willingly worse men than those who promote knowledge and science in the useful arts, with the greatest energy, and to the highest degree. All that we mean to say is, that the parties are in an awkward and false position, in consequence of which, they either virtually reduce themselves to mere stocks and stones, that do neither good or harm; or do mischief in the full and fond belief that they are doing the greatest good all the time.

We have no wish to enter into the politics of this matter, for politics, instead of being our vocation, are our greatest aversion, as wasting more time and talent than all other debateable subjects put together. We wish, however, to get at the truth on this important subject; and if the search after that necessarily assumes somewhat of a political aspect, the fault is not ours.

The fundamental cause of the well-meant opposition to knowledge, and consequent repressing of improvement, which so powerfully affects those classes, seems to be ignorance of their own real position, combined with a continual apprehension that the foundation of it is not stable, and that, consequently, it would slip from under them, if they did not keep hold of it with all their might, and endeavour to cripple those whom they believe to be constantly labouring to take it away. We shall not endeavour to define the difference between these two classes; for though they do not work exactly with the same tools or in the same way, they work together: and if they do not work well, they work diligently.

Their hostility against knowledge and mental acumen, and the sciences, arts, and improvements which result from these, and can result from them only, operates in two different ways: first, by lessening the numbers and paralyzing the energies of the labourers; and secondly, by narrowing the field for their exertion. We have proofs of the first of these in all the districts which are more exclusively agricultural, as well as in the cathedral cities, which have neither manufactures nor commerce, but where the sacerdotal spirit broods supreme; and, like the bird of night, fans the people around into a sort of stupor. We have further proofs in the manner in which churchmen interfere with all establishments for education, and attempt to strangle in their grasp every thing in these which is calculated to give expansion and energy to the mind. They labour most incessantly (at the expense of others) to distribute a semblance of schooling over the whole country, and they let slip no opportunity of getting the influential classes to support them in this. But when one comes to examine this loudly-trumpeted education, of what does it consist? Why, the mechanical processes of reading and writing, perhaps a smattering of the mere practice of common arithmetic, the committal to memory of catechisms and other matters, not one of which is explained or understood, certain mill-horse formalities of conduct, cringing to the great, and disqualification for usefulness in society, may be said to form the whole muster-roll of acquirements, which are so largely patronized by holy men and pious old women. Not an idea is communicated; but, on the contrary, the springs of inquiry and ingenuity are all sealed up; the judgment is reduced to a mere dead letter; and the child leaves the school an unreflecting thing, fit for no useful purpose in the world until the greater part of the schooling is unlearned.

As we ascend higher in the stages of society, the education becomes more sounding in name, and more costly in the acquirement; but we fear that the same general principle—or want of principle, runs through the whole of it. It is a remarkable fact, though one that has been very recently, and even then incidentally, introduced into the reports of committees respecting education and collateral matters, that schoolmasters are the only class of professional persons in England who are admitted to practise their craft without any previous test or knowledge of their qualifications. The utmost care is taken that ignorant apothecaries shall not poison the body; but persons of the greatest ignorance, and in some instances the very ejected of society, may starve or poison the minds of the young with perfect impunity.

Now, if there is one person who, more than any other, requires a thorough examination as to fitness, and keen and constant watchfulness in practice, it is the master or mistress of a school which is largely patronized, and which the children of parents in humble life must enter, or go without education altogether. The parents are not allowed to make any inquiries as to the character or conduct of the teacher; and though they were so allowed, they are but seldom competent for such a task. Therefore their children go to school, without any security or even care on the part of the parents, whether what they do there is to be useful to them in after-life or not.

The case is different with every other person whom even this humble class employ. If baker A. sells them a bad loaf or one which is under weight, they can immediately go to baker B. And the same with the tailor, the cobbler, and every one else they have occasion to employ or deal with. Thus, even they, as customers, excite a commendable species of emulation among the petty tradesmen; and this causes every thing to be better done, and less costly, than if they were restricted to one, into whose character it would be vain to inquire. As we have already hinted, the business of education, which begins thus unpromisingly at the very lowest step, goes on much in the same manner at the very highest; so that if any one breaks away from the trammels of routine, and becomes great, and discovers, invents, or executes great things, it is not in virtue of education, but in spite of it.

We have a strong proof of this in the remarkable difference between the lower class of Englishmen and Scotchmen, even supposing that they have equally attended the local schools in their respective countries. We are not to attribute this to any natural or hereditary difference, for we find that, though the number that are so fortunate bears a much smaller ratio to the whole, yet that the Englishmen who are in this way fortunate, are before the Scotchmen rather than behind them. They have equal acuteness, more subjects to enlarge their minds, and there is a dash of bold-

ness about them, which is far more stimulating and impulsive in matters of science and the arts, than the slow and studied caution of the Scotchman.

Owing to the causes which we have already noticed, the reverse of this appears in the agricultural districts of England. An English ploughman is a mere clodpole, who performs his labour by routine, not by knowledge; and so jealous is he of losing even the most fatiguing and unprofitable labour, that in many parts of the country he collects his neighbour clods, and the whole march to the destruction of a thrashing machine, wherever the farmer or the proprietor has sense or spirit enough to have one erected. The Scotch ploughman, again, performs his work scientifically, does a great deal more of it in an equal time and with a lighter and less expensive team, and if he is a first-rate hand, he will not engage, unless there is a thrashing machine upon the premises. By the way, this same thrashing machine is a most useful and economical improvement, for it does its labour in a much shorter time, at about half the expense, and it thrashes out certain small grains at the top of the ear which no flail would touch; but the quantity of which, on a good-sized farm, would suffice to bring more than a score of bacon hogs into prime condition, year after year. It would be easy to multiply examples that would render this contrast much more striking, but what we have stated must suffice in the meantime, although the subject contains more in it than at the outset one would be led to suspect.

In the manufacturing districts, where the active men are necessarily also the influential ones, and where the power of landowners and parsons is more circumscribed, the contrast is not so striking; and upon the whole, as we have said, England has perhaps the advantage. This advantage, however, is much less in proportion than that of the Scotch in the agricultural districts, and probably the manufacturing districts in both countries, are coming nearer and nearer every day. The reason of this is quite obvious; the Scotch manufacturers and traders are kept behind the English by no law which presses them down, or acts as dead weight upon them; and therefore, any difference there may be between them and the same classes in England, depends upon natural circumstances, and the relative bearing of commerce upon them; but in the case of the agriculturists, which are free, and no law or custom tends to restrain or keep them down in Scotland, while in England, law and custom and deep-rooted habit tend to repress this class, the case is widely different. The landlord himself very generally takes no care of the farm, farther than is absolutely necessary for making it produce anything for political purposes; many of the farmers holding large breadths of land are mere yearly tenants, and liable to be ejected, if they do not strictly obey the mandates of their master, who in many instances is quite the reverse of a conjuror. In addition to this political trammel, in which the English landlord binds up his farmer, the tithes and rates press very heavily upon him; and the landlord, by way of showing that he is a kind and generous man, often breaks down the independent spirit of his farmers, and degrades them to the condition of beggars: the farms are let at rack-rent, estimated by those years in which the produce of them is greatest; and as such years make but a small portion of the whole, the landlord, *of his own kind heart and generous feelings*, as is said in the County newspaper, abates a portion on audit day, according to the unproductiveness of the year. This sounds all very well in a country where the regular object of the higher-titled and beneficed classes is to teach the people that all they receive is from the bounty and generosity of such classes, whose support like beggars all who do not belong to them. But in the eye of reason it is absurd, in the judgment of natural religion it is infamous blasphemy: it appears outrageously false and absurd. The man who lets his lands at so high a rate as that the farmer must have these allowances in unfavourable years, acts dishonourably as a man, impiously as a christian, and ridiculously as a political economist. If the case were fairly stated, it would turn out that these men, who thus boast of their generosity, are the real beggars on the bounty of the nation. Although they may be endowed with all the wisdom of Solomon, as well as adorned with all the glory, they are still "like the lilies of the fields," inasmuch as "they toil not, neither do they spin." In one respect they fall far behind the lilies; for the beauty, the perfume, and all the other desirable qualities of those delightful plants come immediately from the Author of nature, according to the law of nature, and no human being is called upon to contribute a single iota to their splendour; they grow as freely, bloom as beautifully, and smell as sweetly, when the land is desolate of inhabitants, as when it is thickly populated; but take away the rest of the population, and what would be the condition of our lilies? Would a lord get renown, or a churchman wax fat in a country where they were the only inhabitants? We trow not.

The circumstances which we have now enumerated certainly have a strong tendency to the degradation of the rural population of England, and they have a considerable influence even upon that of the manufacturing towns. But they will not account for the difference of education between the two countries,—they will not explain the fact, that while the education at the parochial schools in Scotland tends to excite and draw forth the powers of the mind, the education of the schools in England falls like an incubus upon it, and tends to smother all the mental energies. To what then is this remarkable difference owing? To which we answer, the schoolmasters in Scotland are not only men of education, tried, and known to be such, before they are admitted to their offices; but they are, generally speaking, among the most talented, best educated and greatest devotees to learning and science in the whole country. It is the ambition of parents, in even very humble circumstances, that one of their sons should, if possible, be a minister of the Established Church. For this purpose, the most talented boys are selected, and not those who are suspected to be "good for nothing else," as is but too often the case in England. Boys too so destined, often at a great sacrifice on the parts of their parents, are kept at school until they are fit for the University, and there are some substantial reasons why they should be as good scholars as possible, when they pass from the one to the other. Of these reasons we shall mention only one; but that one throws considerable light upon the whole matter. A person in humble life in Scotland may, from the lowness of their fees, and there being nothing to pay for board, afford to give a promising boy two or three years at the parochial school, without feeling the expense to be very heavy; but, though the fees and the board at some of the Scottish Universities, St. Andrew's and Aberdeen for instance, are not heavier in amount than many an Englishman pay for having his child taught the A B C, yet they are beyond the means of many a parent who has a son most promisingly fit for the University, and whose most ardent wish is to send him there, until he shall pass through the courses of philosophy and divinity, and be fit for a minister of the Kirk. In aid of these there are small exhibitions,

called bursaries, which upon examination and a comparative trial, are, we believe, very fairly and honestly bestowed upon those who deserve them the most. By the aid of these, parents in very humble life are enabled to procure University education for their promising sons, at little more expense to themselves than that which they paid at the common parochial schools. Not only this, but a youth of superior talents may be appointed to read with or be a sort of tutor to the son of a wealthy man, in which case he may not only be able to pay the whole of his own expences, but to save a little surplus for his parents.

The grand object of course is, that the student shall become a minister of the Kirk; but the law of patronage has broken down the purity of it; and the most talented man in humble life, unless the wealthy man to whose son he acts as tutor has livings in his gift, or influence to procure them—the most talented youth has small chance of ever gaining a pulpit. There is another way; the youth may become tutor in the family of some nobleman or gentleman, who has a church-procuring power; but this is a degrading office, and fit only for a sycophant. The menial offices which such a tutor must perform, and the subordination which he must show, not only to his employers, but to the chief and the confidential menials to the establishment, are hard to be submitted to by any young man of spirit; and therefore, though such tutors, when they can prostrate themselves with due humility, are pretty certain of church livings in the end, yet the degradation of the tutorage is such as can with difficulty be borne by any young man of spirit. The consequence is, that the very choicest of those Scotch students from the humbler classes are thrown back upon society, with notions and qualifications far higher than are required in the common business of his rural life. They therefore become parochial schoolmasters, highly qualified for their scholastic duties; and as, in the richer agricultural districts especially, they generally fill up their time by acting as surveyors, auctioneers, and other avocations which require a little learning, they have better incomes than the majority of English curates, and occupy a pretty high place in their localities, and bring up their families in a respectable manner.

Under teachers whose talents and acquirements are so well ascertained, and who are regularly superintended by the ministry of the district, it follows as a matter of necessity, that the education must be much better than it is in the English schools, even those that have an L. L. D. or A. S. S., as chief manager of the mercantile part of the business, and are attended by the sons of the comparatively wealthy. We have said, that the Scotch are under the superintendence of the local clergy, or members of the Presbytery; but this superintendence must not be confounded with that surveillance which the English clergy exercise over the national and patronage schools, and which they labour incessantly to extend over every place of education, and indeed, over every opinion. Religion is not neglected in the Scotch schools, any more than in those English ones which are understood to enjoy the most saintly patronage. The only difference is, that the English schools have ten times more of the form of religion, and the Scotch ones a hundred times more in reality. Besides this, both teachers and superintendents take a delight in distinguishing the most talented, and the name which a lad gets at school often becomes the spur, which urges him on to literary and scientific eminence in future life. Then, the fees at those schools are so moderate, that even a labouring man, if frugal and prudent, can give his children the benefit of them; and whatever may be the difference of station and rank among the parents, that goes for nothing in the school, for the best scholar is always the most esteemed and honoured. The reader will at once perceive, that this mode of education greatly increases the number of persons from among which an Engineer, or any other professional man has to be selected; and though the population of England exceeds that of Scotland manifold, the difference of the numbers from which professional men can be selected is very small in proportion. It is in the country where this difference is most general, and therefore most striking, but it holds among the labouring classes in the towns; and indeed, extends like a mental paralysis over the majority of the English nation.

In the towns indeed, and among manufacturing and mercantile people especially, there are stimuli, which not all the the heaps of dulness which we have described can keep down; and in these stimuli have originated almost the whole of the engineering improvements of the country. The object of the whole of these, is to contribute to the cheapness and the distribution of commodities, and they may be divided into two classes,—facilities in the workshop, and facilities of transfer from one place to another,—nor is there among them any one great contrivance which goes directly to improve the value of the land, and so increase its produce. This arises from the conduct of the landholders and others, which we have described as having, for its express object, the trammelling of mind; and at the same time it diminishes the numbers from which Engineers could be selected, it narrows the field for their exertion; but we must reserve this point for a future occasion.

ON SUPPLYING TOWNS WITH WATER BY AQUEDUCTS AND PIPES.

TO THE EDITOR.

On comparing the ancient and modern methods of supplying cities and towns with water, the former by aqueducts, carried on one level, or with a slight descent, and having the water open to the day, and exposed to the action of the atmosphere throughout its whole course, and the latter having the water conveyed in pipes that may ascend and descend, and be accommodated to the natural level of the ground, without any expense of deep cutting, embanking, or bridge building;—on comparing these, one naturally gives the preference to the modern system, at least in so far as the mere transit of the water is concerned. By means of it the water is brought from the source of supply to the point of distribution in pipes—cast-iron ones in all the more recent erections. If there is a certain head of water at the point of supply, that is, if it is considerably elevated above the point of distribution, the water will flow along the pipe of its own accord; and if the head of water at the supply, the elevations, depressions, and length of the line, with the diameter of the cylindrical pipe, are given, the quantity which the natural pressure of the water will discharge in a given time, at the point of distribution, may be determined by calculation. The problem is however a mixed one, many of the circumstances upon which the results depend being matters of experiment; and every line requires some modification from its own character and circumstances; so that the discharge by one main cannot be accurately deduced from that discharged by another by simple comparison. It is essential that, along the whole of this main and the ramifications, until the points of supply to the people are arrived at, the air must be excluded, otherwise the system will not work. It is

also to be borne in mind, that the interior surfaces of the iron pipes must become oxydised in proportion as the water is more or less loaded with earthy salts; and that this must have some effect upon the quality of the water as discharged from the pipes. If wooden pipes are used, and the wood not thoroughly seasoned, the sap of it is apt to give a taste to the water; and if the interior of the wooden pipes is in incipient decay—or what is termed "foxed," both the smell and taste of the water are very offensive, —far more so than can ever be the case in the very worst-conditioned iron pipes.

There is still one advantage in the system of pipes, which cannot be obtained in that of aqueducts: the water can be forced by means of steam engines or other mechanical powers, so that much more may be transferred; and it may be raised to much greater heights than can be done in an open aqueduct. In that there is no means of forcing an increased supply, neither is there any of getting over an intermediate point, if it is not below the level of the point of supply. The only way of accelerating motion in an aqueduct, so as to make the water move with a little more velocity, is to draw it quickly off the discharging end; and as to obtaining a higher level, there is no means whatsoever.

Such are the principles upon which we compare the ancient and the modern systems, in so far as the mere transfer of water is concerned. With the ancients these aqueducts were, in countries of diversified surface, among the most expensive of their public works, and some of them gave scope for no small degree of architectural display. We know not whether, in a perfect system, the modern means of supply are less costly, because individual houses, and even single rooms are supplied, which does not appear to have been the case among the ancients. They had public fountains; and in many instances, these fountains were contrived so as to be highly ornamental as well as useful. The modern works on the other hand, with the exception of engine houses, stand-up pipes, filtering beds, and other auxiliaries to the system—of which however they form no essential part, make no display, architectural or otherwise. They lie below ground in the country, and below streets and buildings in towns, and a stranger who knew nothing about the system might perambulate London for a month, without the least idea that water pipes are ramified over the whole of it, something after the same manner as arteries are through the body of an animal. But though there is no public display in this—no single object to look at which can be regarded as an ornament to the locality, there is a wonderful saving of time, and increase of domestic comfort. Take the whole population of London for instance, and say that there were five hundred public fountains, 3000 individuals would have to be supplied at each fountain; and at the usual allowance, that would be 600 domestic servants to go to the fountain for water as often it as were necessary. In towns which have even a moderate population, and where the supply is still by fountains, the idle habits and demoralization which results from the attendance of servants there would not be credited, except by one who had actually seen its effects. All this is got rid of, and a vast deal of time saved, by serving the water to houses, and therefore, in so far as the distribution of the water is concerned, the modern system is wholly good, without the slightest admixture of evil. It is good in another point of view; and that is in the case of fires. If the mains are constantly kept full, and with a sufficient pressure on them, and the firemen promptly at their post, and active when there, most accidental fires could be extinguished before they spread to any great extent. Nominally, the supply of water, the fire brigade, and all the other means for controlling the devouring element, are superior to what they formerly were; but as the relative number and destructiveness do not appear to have diminished, one is tempted to think that there is "something rotten in the state of Denmark:" that is a point which however we shall not discuss in the mean time, because it is at all events superior to a fountain supply.

Having stated thus much, we shall shortly consider another question: What are the different effects of the aqueduct exposed to the air and the pipe hidden in the earth, upon the water which they transmit? This is an important question at all places where a dense population have water supplied to them, either by the one of those methods or by the other. It must be understood and kept in mind, that the aqueduct is generally, if not invariably, supplied with river water,—that is, with water, the greater portion of which has flowed freely exposed to the air over a considerable distance before its arrival at the aqueduct, and it also receives an accession of rain water through all its course, in the majority of countries and seasons; and as this accession consists of water in the purest state in which it naturally exists, there is an obvious advantage from the aqueduct in rainy climates and seasons; but river water, after it has flowed a considerable way in a channel in which there are no salts to be decomposed, is the next in purity to rain water; and, therefore, the usual mode of supplying water by aqueducts, is the very best for obtaining water well adapted for all domestic purposes. This improvement is in the transparent water itself, and not by the removal of any visible substances which might float in it; and this is a decided advantage. In the pipe, again, the water can receive no purification from the atmosphere or anything else; but, on the contrary, its passage through the iron pipes must tend to impregnate it still more with earthy salts; and thus deteriorate its qualities for many domestic purposes. It is true that water containing a little of these salts sparkles more in a glass, and is sharper to the taste when drinking, than water which is perfectly pure. But it ought to be recollected that drinking is only one of the uses to which water is applied, and it is doubtful whether it is one of the most important of them; and, farther, it is doubtful whether water, impregnated with those salts, notwithstanding its sparkling appearance and its sharp taste, may be equally wholesome as pure water as a beverage. If those salts amount to a given quantity, the water becomes a medicine; and we very much doubt whether any medicine can be a wholesome ingredient of food or drink, to a person in good health. Indeed, we feel all but convinced that it cannot be wholesome: the use of the medicine is to bring some system or function of the body up to a healthy state, and balance to the rest, and, consequently, if the body is already all in this state, the medicine will disturb the balance, and, according to its nature, either over-excite or under-excite that part of the system on which it acts. We have a practical corroboration of this in those affluent and not overwise persons, who have nothing to do but bolster and cobble their health—that is, who actually do nothing but this. What by overworking their stomachs, and what by keeping unseasonable hours in the gay time of the year, they do get a little out of order, and as the least trifle sadly deranges such delicate health as theirs, away they whisk to the mineral waters. The journey there sets them all to rights; but they give themselves no time to reflect until they have swallowed some dozen gallons of the water: then, "they feel so charming, and the water is so beneficial to

health, that from their very souls they pity those hapless wights who have neither means nor time for being partakers in the blessing." Every season they go there as regularly as a certain day comes round in the almanack; and season after season they feel more charmingly well; but the crow points his foot around the lady's eyes, the gentleman loses the calves of his legs,—except haply one to the two legs,—and they totter to their graves sooner than other people, in so lean and husky a condition, that old Death finds it impossible to make a decent meal of them.

But, as we have said, drinking is only one of the domestic purposes to which water is applied, and far from being one of the most important ones. It is wanted by the scullion, the cook, the housemaid, and in short by every one who is engaged in preparing food for the table, or in promoting cleanliness of every description. In all these cases, soft water does its office much better, sooner, and more economically than hard water; and as much of the comfort of a family depends upon this, the object is to get the family supply as soft as possible. The reason why hard water is so much less serviceable, is easily explained. The earthy salts combine with the alkali of soap, and leave the oil or grease, which is frequently of the most impure or offensive kind; and the process of washing, instead of taking grease out of the things washed, as is the case with soft water, merely soils them further with the grease of their decomposed soap. When used for culinary purposes, it does not draw a tincture so well from tea or coffee, and all substances in it boil hard, so that whatever may be the effect to the taste, they are difficult of digestion, and less nutritious. It has been argued, that some vegetable substances are more green and crisp, and appear better on the table, when boiled in hard water than when boiled in soft. This may be true, so far as mere appearance goes, but it is no argument for the goodness of the vegetables, as they would look still greener if a handful of rusty halfpence were boiled in the saucepan along with them, and yet such a process would give them a poisonous quality.

A question as to the purity of water is often raised in London, where so large a supply is required, and the quality is so essential; but the objections are generally taken to the mechanical purity of that water, and not to its chemical composition. The reason of this is pretty obvious; a small portion of the water can be magnified many thousands of times; and the larvæ of insects and other small animals which are contained in it are of course magnified at the same time. Then, if the magnified image of the drop is thrown upon a screen, a fearful scene of horrid shapes, motions as quick as lightning, and carnage, is displayed. Many of the little things are carnivorous, and gobble up their neighbours without any ceremony; and a larva of a Dytiscus beetle, or of a dragon-fly, is ever and anon dashing across like a great whale, and devouring them by wholesale. All this, it will be observed, is a proof of the chemical purity of the water; for if it were not pure in this respect, these animals could not live in it. This, however, is overlooked; and as the horrible shapes are palpable to the sight of ladies and gentlemen, they conceive a perfect horror at the water. They do not know, or, which is the same thing, they do not bear in mind, that these little creatures and their motions are magnified at the very same rate as the drop of water, or that if they were to look at the water with their own eyes, without calling in the microscope, the water would appear transparent. Another thing overlooked is, that, supposing the actual size of the creatures to be ten times greater than the microscope showing them, they would still be perfectlyharmless, and a gallon of the water might be drunk every day with perfect impunity, so far as they are concerned.

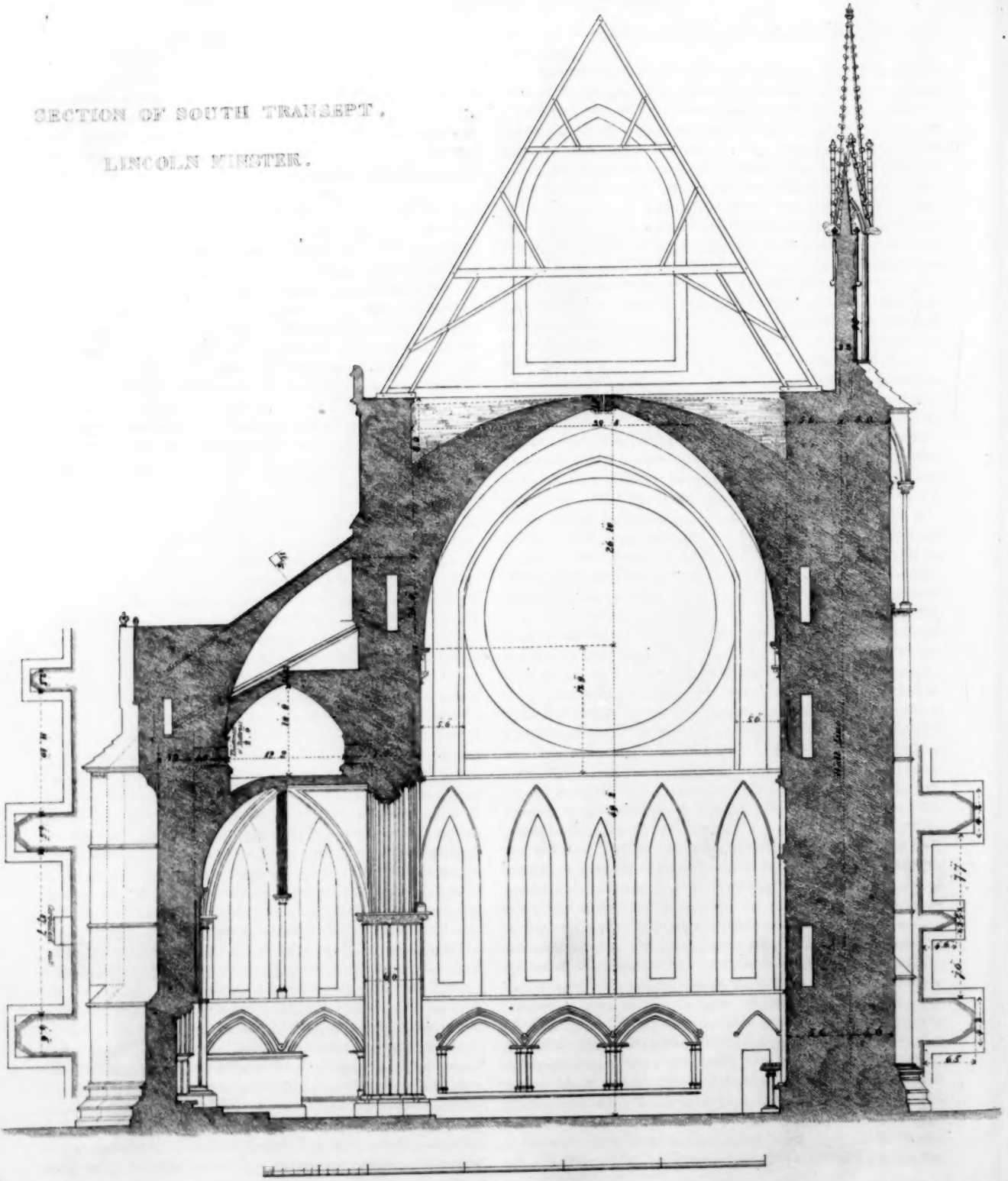
Still, however, it is upon these grounds that sage philosophers, learned doctors, and other persons of sounding name take up their maledictions against the water with which London is supplied, and the public, worshipping their nominal wisdom, tread willingly in the steps of their real folly. Now, there is a simple and obvious axiom which applies here, namely, that whatever is mechanically mixed with the water can be separated from that water by mechanical means; and, therefore, if there is no chemical taint, filtration, if rightly performed, will render water as pure as any one can desire. Hence, if we are to ascertain how a supply of the best water for any great city, London for instance, is to be procured, we must look to the sources whence it is originally derived.

In stating the quality of water that flows or springs from any particular stratum, it is impossible to speak universally, because strata often contains very different substances, at very short distances from each other. The purest of all water is the rain of heaven; because it rises by evaporation, and no saline or metallic ingredient is raised by that process. The next in respect of purity is, perhaps, that which trickles out from the fissures of primary rocks, such as granite, mica slate, and indurated quartz slate. That which comes from clay slate is apt to be more or less impregnated with alum, and water from primitive limestone generally contains a small portion of lime, which makes the water look bright and sparkling, but gives it a little hardness.

Water from the more perfect volcanic strata, the trap and basalt family, is also in general very pure; but as there are no rocks in the valley of the Thames, those circumstances do not require to be taken into consideration, in ascertaining which is the best water wherewith London can be supplied. The head springs of the Thames and its principal branches generally trickle out from the surface, or near the surface, of the chalk downs, especially where these downs are capped with the tertiary formation. Sometimes the cap contains a good deal of iron, and the water is tainted by that; but generally it comes out clear and sparkling, and contains a portion of lime. In passing over the tertiary strata, the water may become mechanically foul; but it rarely takes up any chemical ingredient. This water is accordingly the purest and softest that can be obtained in such a valley, and the further that it runs exposed to the atmosphere it is always the softer. Upon this principle, the water of the Thames is, next to rain water, the softest and the best fitted for domestic purposes that can be had; and, notwithstanding the frightful contaminations which are said to result from gas works and other manufactures, I am inclined to think, that where there is considerable depth, water may be taken up from the bottom with little or no contamination, except what is mechanical. The water companies, yet, however, act upon the reverse of this principle, and have the dolphins near the banks, so that if there is any real contamination in the water, they are sure to have their share of it. As these companies now endeavour to obtain their supply as far up the river as possible, the water has to pass through a considerable extent of pipe, and, in so doing, it is apt to be more or less impregnated with iron, or to become a little harder than if it were delivered from an aqueduct into the service pipes. It is true that most of them have reservoirs, in which the water is exposed to the air, and the hardness in so far corrected; and if the reservoir is large enough it may be rendered almost entirely soft. The New River—it is now the oldest contrivance for the supply

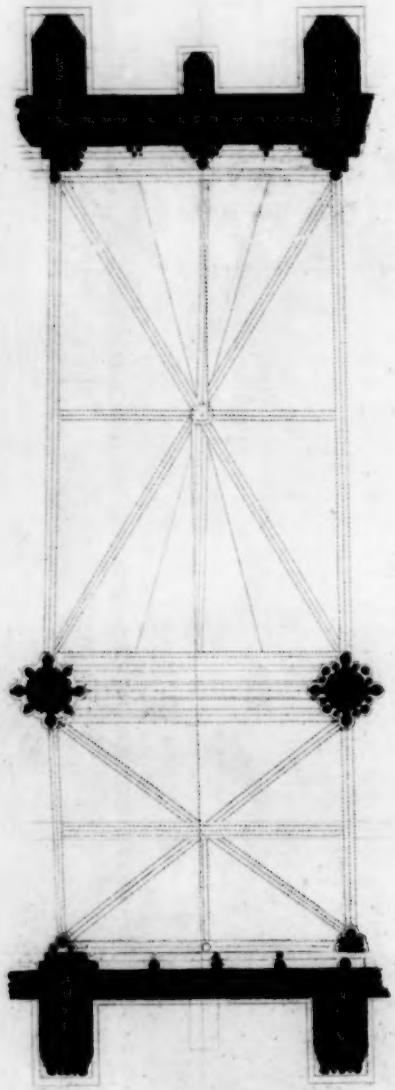
SECTION OF SOUTH TRANSEPT,

LINCOLN MINSTER.



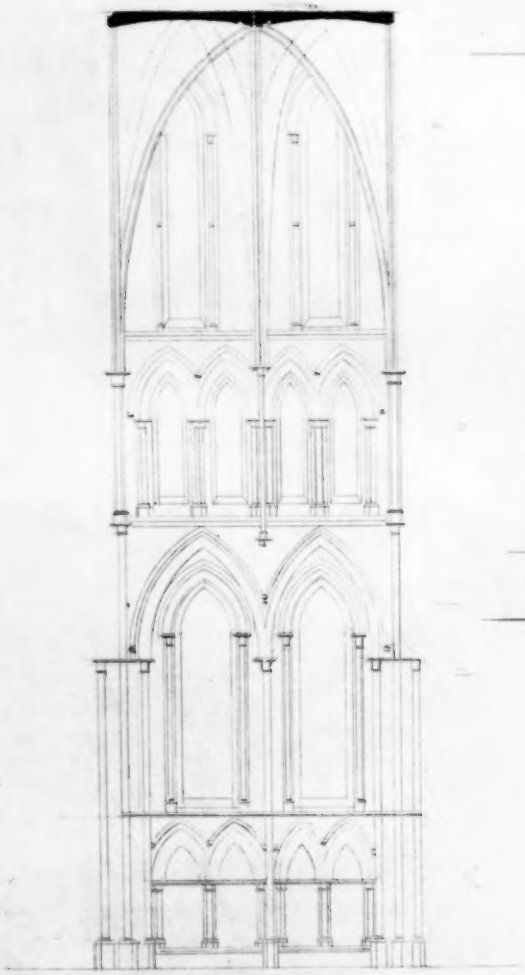
London, Published by W.S. Orr & Cº Amen Corner, May 1. 1841.

Nº1.



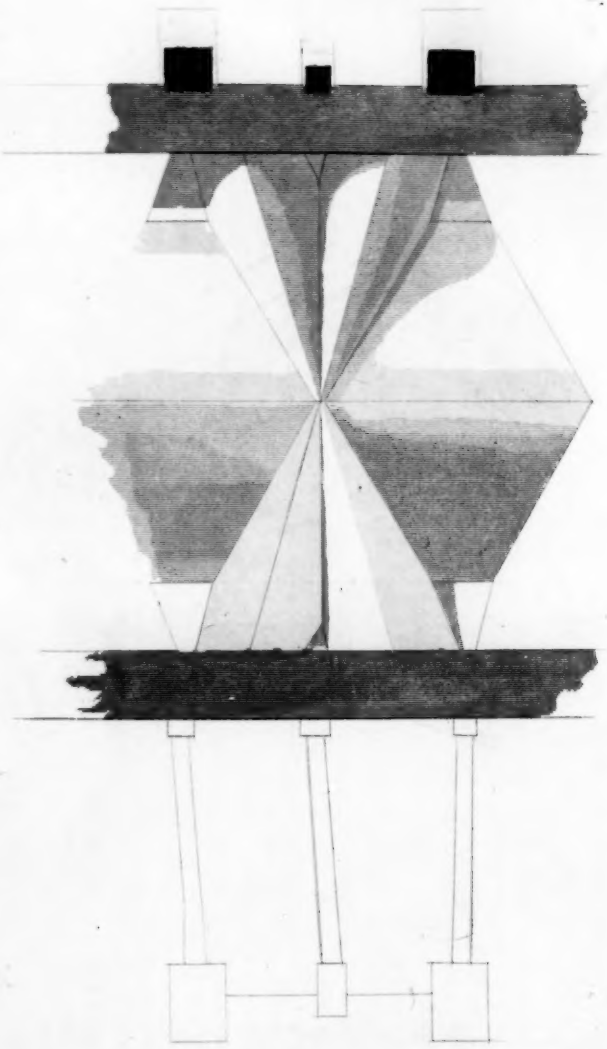
GROUND PLAN OF ONE BAY.

Nº2.



ELEVATION LOOKING WEST.

Nº3.



PLAN TAKEN ABOVE VAULTING.

SCALE, ONE INCH TO TEN FEET.

Stⁿ TRANSEPT, LINCOLN.

Drawn by F.L.Penrose, Esq.

of the town—has this advantage, that it comes slowly along an aqueduct to almost the very point of delivery; and thus the water of the New River is, perhaps, the softest and the best fitted for general purposes of any in London. From its exposure to the atmosphere, it may be mechanically more foul than the others, but as we have already said, this foulness may be removed by mechanical means.

Two projects have of late been alternately brought forward and again lost sight of, for supplying London with water purer than that of the Thames or New River. One of these is the obtaining of a supply partly from the springs and brooks near the northern chalk downs, and partly from Artesian wells, carried to such a depth as might be found necessary. Now, the waters of the springs and brooks is not, and cannot be, one tittle more pure than that which feeds the Thames or the New River, and as for the water of Artesian wells, it is always in some degree hard, and the hardness is often considerable. Therefore, this is not a very wise scheme; for it is neither more nor less than bringing to London, at great expense, water which is really worse than that of which an unlimited supply can be obtained at much smaller cost; the length of main pipe required in this case would be very considerable, and, therefore, the moment that the inside of the pipe became oxydized, the water which it transmitted would become tainted with iron.

The alternating scheme which appears when this one vanishes, just as any of the lights does in a revolving lantern, is exactly of the same character with this one, though on a somewhat smaller scale, and performable without the aid of Artesian wells: it consists in taking the water of the river Wardle, somewhere about Carshalton, where, except a little lime, it is very pure, and carrying it in a drain to some of the high commons on the right bank of the Thames, there to remain for some time in such a reservoir as may be necessary. From this reservoir, it is to be carried to London, crossing the bed of the Thames in a flexible main, something like what was contrived for carrying water across the Clyde, at Glasgow. The last main would, however, be of very considerable length, and would contaminate the water with iron, though not to such an extent as in the alternating case.

I must confess that I do not like either of these schemes: they would contaminate rather than improve the quality of the water, and they would burden the consumers with the expense of new works and additional establishments. Both of them are schemes grounded upon the fright into which the weak are thrown by the frightful delineations of the mechanical impurities which are shown in the present supplies, when not filtered. If any of your correspondents reply to these remarks, you may hear from me again.

AQUARIUS.

May 6, 1841.

REMARKS ON SOME PARTS OF LINCOLN CATHEDRAL,

BY F. L. PENROSE, ESQ., OF MAGDALEN COLLEGE, CAMBRIDGE.

THE Section (*See Plate*), is taken through one of the bays of the South Transept of Lincoln Cathedral. It is chiefly remarkable on account of the extreme lightness of the abutments; one entire buttress on the eastern side, as is shewn in the section, has been cut away: but the western side is equally remarkable, the buttresses having very little projection. This part of the cathedral is one of the earliest specimens of pure Gothic in England.

The south transept of Lincoln was built by Bishop Hugh Burgundus, who died in 1200: it has a good deal of resemblance to some of the Normandy cathedrals, especially in the vaulting; which, instead of being supported from pier to pier, has a rib which springs from above the joints of the arches: it is through this rib that the section is taken; the part of the vault which this rib carries, though little more than a quarter of the whole, on each side of the ridge rib, contains about 400 cubic feet of stone, which ought, according to all principles of equilibrium, to cause the resultant pressure to fall beyond the buttresses; but since it stands quite secure, this is evidently not the case: it is therefore probably kept together to a certain extent by the cement. The part of the vaulting, which is carried by the rib over the piers, will be found also to be too much for its abutment, unless an allowance be made for the cement.

The drawings do not seem to require much explanation. The dotted lines in the elevation, No. 2, shews the traces which the vault makes against the wall, where it is hid by the other parts. The whole is drawn from sketches and dimensions made on the spot by myself.

It will be observed how very much the directions of the flying buttresses, which are shewn in the plan No. 3, and other parts, being so far from square with the walls, &c., would shock modern builders' ideas; but it is only on paper that they look disagreeable; they do not in the least degree take away from the effect of the building.

It is singular that Mr. Ware, in his Treatise on Vaults, &c., though he takes a good many sections of Lincoln, suppresses this altogether: it probably does not suit his theory.

It is a pity that some general distinctions of the different styles of the Architecture of the Middle Ages are not in use amongst us; of the three terms which Rickman adopts, there is but one admissible, namely, perpendicular; why not call the style which he so unmeaningly calls *decorated*, curvilinear? as for *early English* it is a miserable term: *the lancet style*, though not distinctive enough, is a far preferable term.

ROYAL ACADEMY: ARCHITECTURAL DRAWINGS.

WITH the contents of the Exhibition generally we have nothing to do: we are not called upon to express either our admiration or our disgust at Turner's extravagances—his framed messes of eggs and spinach, of mashed turnips and mustard; or at Etty's sansculottes,—ladies and gentlemen exhibiting themselves in that state of innocence, which the police would treat somewhat unceremoniously; and which subjects, we understand, are especially intended to edify the saints and quakers of both sexes,—including the rising generation also, who stray into the Royal Academy. Neither is it any duty of ours to examine the host of faces and phizzes that stare upon us from every side—the supereminently fine dandies from the D'Orsay downwards, or those magnificent masses of millinery in which Chalon, infinitely more modest than Etty, encases his ladies; and we verily believe he would dress up Eve herself in blonde and lace, and with jewellery *à discretion*.

Let us enter the architectural room; and there, out of nearly two hundred subjects—minus the oil pictures thrust in here, to keep them out of harm's way, we suppose,—there are scarcely a score which deserve notice as designs; that is, notice for commendation;

since there are many which deserve to be pointed out for reproof, or which, if passable in themselves, have no pretensions whatever to be exhibited as works of art. It is true they serve to cover the walls, just as well as better things; yet it would be better were they themselves away, if merely because there would then be an opportunity of our seeing some of those which are now put almost out of sight, whereas, it would not be amiss were several of those we can inspect, kept out of sight altogether. Whatever may be the case with the other rooms, this part of the Exhibition would always be improved by a good deal of pruning and weeding. *Quality*, not *Quantity*, should be attended to by those who have the arrangement of it; for one quarter of the number of drawings now hung up, would produce a far more favourable impression. We go to see talent, not the want of it,—to look at designs wherein some ideas and some taste are displayed, not to stare at things which are so frightful, that they absolutely set our teeth on edge to look at them. But provided it serves to fill up a gap,—no matter what it be,—all is fish that comes to the Academy's net.

It would seem that the hanging committee are mere executioners, certainly not judges; nor does there seem to be any one to judge for them, because in that case some of the drawings we now see, would not be admitted even were there nothing else to fill up the spaces they occupy; and to say the truth, we should prefer a few blanks on the upper part of the walls to most of the productions—*prizes* they cannot be called,—stuck up there, and to be seen only in the catalogue. We know not how far the authority of the Professor of Architecture extends, but presume, that if not absolutely required to do so, he would be allowed to exercise some sort of jurisdiction over this portion of the Exhibition, and to select or recommend such designs as ought to obtain a preference. This would tend to keep up the respectability of the architectural room rather more than is the case at present. That it is not done, however,—that no principle of selection is attended to, we can affirm pretty confidently, having known more than one case where, when an architect has sent in three or four designs, the best have been excluded, while the inferior ones have been admitted. We do not intend to say that this has been done with a malicious purpose, but merely because the frames of the accepted drawings were found to fit it with the rest more cleverly than the others. Yet, if this serves as an excuse to the hangers, it serves also to condemn the system, or rather want of system, which leads to such preposterous results. Hardly less preposterous is it to say, that the evil is one which admits of no correction, when the walls of the room convince us, that many things might have been turned away, and the exhibition would have been improved by their absence, while some others could then have been hung to far greater advantage than they are at present. However, so long as the absurd and mischievous system now adhered to, does not affect those architects who are also academicians, there is little hope, perhaps, of its being attempted to be reformed by those who have the power of doing so.

At all events, it is consolatory to find, that the Professor has not forgotten Number One, or else that good luck has eminently befriended him, for his drawing occupies the most favourable situation in the room. We will therefore make that number (993 in the catalogue), the first for remark. It is described merely as a "Study for the front of a public building," but must be instantly recognised by almost every one, as that for the West Front of the Royal Exchange; consequently there is no occasion for our describing for what is generally so well known, the same view having been published in "The Westminster Review." The drawing itself is certainly an exceedingly tasteful one, quite captivating from the artistical feeling which pervades it. In our eyes this is no small merit as far as it goes, but then in those of the Professor himself, it should be rather the reverse: at any rate it is totally at variance with his own precepts, delivered *ex cathedrâ* to the students, when he recommended the utmost sobriety—self-denying abstinence from aught approaching pictorial treatment in architectural designs, advising no more than the simplest indication of shadow, by mere washes. Well, we suppose such advice was intended for beginners only; but then again, his own practice does not accord at all better with his doctrine in what is more important, for it certainly does look like inconsistency, when, cautioning others against aiming at picturesque effect and character, he here makes them the leading qualities of his composition. In fact, his design is studiedly picturesque, is marked by all that richness and variety, which would recommend it to the eye of a painter. The various parts are all combined with reference to such effect rather than to architectural propriety. Its very vices render it picturesque,—its large three-quarter columns supporting nothing but the blocks of entablature breaking over them; the accumulation of ornament spread over the whole,—the number of breaks throughout,—the arbitrary piling up of one part over another—the turrets, the obelisks, (now for the first time stuck on two of the pedestals of the balustrade, and which have certainly no propriety, nor much more of elegance in themselves), every thing, in short, announces that picturesque decoration has been the principal aim. To this we should not so much object, were it not that there is also much that is in a bad taste, and seemingly dictated by nothing better than caprice. We do not, however, go so far as to agree with the newspaper critic—in "The Times" if we mistake not—who has described it as looking like a huge gin-palace.

Albeit he is an R. A. elect, Mr. Hardwick has not sent a single drawing to the Exhibition this year; and yet if he was at a loss for a newer subject, he too might have given us "a study for the front of a public building," viz., a study for improving the present façade of Goldsmith's Hall, by clothing the now offensive nakedness of the ground-floor part of it. Mr. Cockerell could very well spare him a little of the finery in his design for the purpose.

Barry has sent but one design, nor is it that for the terraces in Trafalgar Square, which we rather expected to behold in the exhibition; yet certainly one quite as gratifying, or rather more so to our curiosity, it being a perspective view, (981,) showing the south and west fronts of the future Bridgewater House. There was at first an *on dit* that Lord Francis Egerton was about to employ Sir R. Smirke as his architect, had which been the case, it would have been easy to predict beforehand what sort of an affair it would have been,—something about as stately and dignified, and as imaginative withal, as the Union and Conservative Clubhouses, or as the new buildings of the British Museum. If his Lordship actually entertained such intention, he has shown his judgment by repenting of and abandoning it; for should the design we here behold be carried out to its full extent, he will certainly possess the noblest mansion in town,—in fact, the only one that can really be termed palatial in character. On this occasion, the architect has deviated from that peculiar style of Italian, by which he has distinguished himself in his two buildings in Pall Mall, for, instead of giving us another *astylar* composition, crowned by a bold *cor-*

niciône, he has adopted the more usual mode of a columnar ordinance raised upon a rusticated ground floor. Yet, if so far there is a strong verbal similarity between this design and what we are accustomed to see, there is an indescribable difference as regards character and effect; since the mode of treatment is diametrically opposite to that which prevails in Sutherland, Apsley, Uxbridge Houses, and other mansions, intended to be dignified, yet so insipid as to be almost insignificant. Charles Barry is not the person to commit architectural sins of that kind, for, whether otherwise original or not, he generally impresses his subjects with the charm of geniality and gusto. No doubt he has been highly favoured by opportunities, yet not more so than many others, whose opportunities have enabled them to produce little more than so many architectural failures. For the singularly happy taste displayed by him in the south front of the Travellers' Clubhouse, he certainly was not indebted to any particularly favourable circumstances, the mere subject itself being not at all more propitious than such a one as the City Club-house, for instance, which is nevertheless its reverse in almost every respect—a piece of respectable mediocrity and dulness. However, we are now wandering into discussion, which, if necessary, we may spare for some other occasion; so let us hurry back from Broad Street to Cleveland Row and the Green Park. There is no doubt that Bridgewater House will be a very superior specimen of the Italian columnar palazzo style. Still we cannot help desiderating somewhat more of invention, or rather wishing that, instead of following Italian models too closely step by step, Mr. B. would now essay some fresher combinations. The Florentine style—hardly known at all in this country—might be made to furnish much that would be both new and valuable.

ARCHITECTURAL COMPETITIONS.

Sir,

Without my entering into the complex and intricate subject of Competition generally,—relative to which, by the by, some very good hints were thrown out in an article in your first number,—allow me to offer one or two suggestions which can hardly be objected to, unless mystery and concealment be undisguisedly asserted to be the privilege of committees.

Surely it would be more satisfactory and more honourable, were the names of all the parties composing a committee to be communicated to architects, together with the instructions relative to the intended building. Further, as it is hardly to be supposed that every successful design has been chosen unanimously, it would certainly be not at all amiss, were it afterwards made known by what majority the choice has been carried, and who were the parties voting for or against it,—for the election ought to be made by open voting and not by ballot. This last measure would ensure some little sort of responsibility on the part of committees; and those who do not care so far to expose themselves to public opinion, ought not to have any thing to do with such matters, but leave them to those who are either more honest or less timid,—to those who can form a judgment of their own, and are prepared, if necessary, to defend it.

Surely it is important to know, in every case of the kind, what is the exact majority, it making a very great difference whether it amounts to no more than a single vote, or whether the minority consists of a single dissentient one. Besides which, it may happen that among the dissentients, there may be an individual whose opinion in matters of art ought to have more weight than that of three or four other members of the committee, or else *vice versâ*, so that his vote would add considerably to the majority in favour of the selected design.

It would be both important and interesting to know for instance who were those who voted for Mr. Railton's design in both competitions for the Nelson Monument,—whether they were precisely the same parties on each occasion, or whether there was any difference as to the majority, numerically or otherwise, on the first and the second occasion.

It may perhaps be thought that were the names of the parties on committees communicated to architects beforehand, it might sometimes lead to previous canvassing or tampering with them on the part of the latter. I should think not, because such an attempt might be perilous, and bring exposure and disgrace upon him who should venture to make it. But at all events, there could be no valid or even plausible objection to publishing a full statement of the votes after the decision had taken place.

I remain, Sir,

Yours, &c.,

An Architect.

PROJECT
FOR A SUSPENSION ROAD ALONG THE THAMES.

TO THE EDITOR.

Sir,—Will you allow me as much space in your Journal, as merely to hint that I have projected a perfectly new mode of extending a road along the Thames, between the northern abutment of London Bridge, and some point in the vicinity of the public offices,—say Scotland Yard or Whitehall Place. This is all the length which I think necessary for connecting the city with the West End of the town, and opening a short and pleasant passage for carriages, equestrians, and foot passengers. I would propose strictly to prohibit all transfer of goods or carriages used for the conveyance of goods along this line, and confine it exclusively to the people, in whatever style they may afford or choose to travel. At the same time it ought not to be the job of a Joint Stock Company for the sake of making money, but a public way, executed at the public expense, and free to all classes of the community, as well as to all foreigners who may visit the Metropolis. The structure which I would propose, is a series of Suspension Chains, as wide apart as might be consistent with strength and economy, and supported by well-founded and strongly built piers of granite, wherever one chain abutted on another. To this a proper carriage way and foot passage, separated from each other by a railing, would be suspended; and the rails of the external parapets might be made highly ornamental, nor would there be any objection to making the upper parts of the piers of cast-iron, as that would give lightness to the structure, without impairing its durability. The road might be carried so far from the shore, as to leave room for the coal barges and other craft at the wharfs; and the great extent between pier and pier would leave the access to the wharfs as free as it is at present; and then there would be sufficient space on the Surrey side for the barge navigation up and down the river. Thus there would be no property to purchase,

and no compensation to make,—expenses which have rendered all previous schemes for a road this way quite impracticable; for the only cost here, would be that of the structure itself, which admits of previous calculation; and thus the total cost could be easily ascertained before the works were begun.

This road should be brought to the exact level of the bridges, and made to arrive at and leave a pier, by which means passengers may join or quit the road at any of the bridges they choose. If, as has been mooted, a spacious street were carried from Southwark Bridge to the Mansion House, the Bank of England, the Exchange, and all the public buildings and offices in that part of the City, it will be very accessible from the West End.

This, in brief, is an outline of my proposal; and I send it you in the hope that some of your correspondents may work out the calculations, and thus furnish a first and pretty closely approximate estimate of the expense.

I know that the idea is original; that the execution of it would be useful, and not a little ornamental; and therefore I enter my caveat against any liers in wait for other people's ideas, attempting to purloin it, and especially to make a joint-stock job of it.

Some may suppose that I ought to have entered a caveat at the Patent Office, or even taken out a patent. But I have great dislike to the management of the office, and indeed, to the whole system of patents as conducted in this country. Honest men, if they have men like themselves to deal with, have no use for patents any more than they have for signing agreements or taking pledges that they shall not break the laws of their country or of common decency; and the very idea of a patent involves in it a declaration, that all schemers, and indeed all executors of scheming, are rogues. This I do not believe, nor do I think that one invention more would be appropriated, though the Patent laws were torn from the statute book. Patents are generally mere puffs for the patentees; and if there is one article worse than another, it is sure to be a patent article.

Having said thus much, I subscribe myself,

A Projector.

Note by the Editor.

We very anxiously and earnestly impress upon our correspondents—some of whom we know to be well qualified for the task, to examine the ground, mark out all the details of this project, and see and publish what would be the absolute cost. We grant that there are some points in the construction of it, which do not occur in that of ordinary chain bridges of a single catenary, and these may be stumbling-blocks to those engineers who follow in the wake of each other, like wild hogs in Westphalia, and feed their hungry brains much in the same way as these are said to feed their corporeal stomachs. But discounting these,which we would persuade ourselves are but a small per-centage on the whole, there could not possibly be any lack of talent to meet and overcome the trifling novelties to which we allude; and these being once overcome, all the rest is plain sailing,—so that any lubber may direct the course and make up the log.

In our humble opinion, and it is a very humble one, this is the only practicable scheme that ever was broached for obtaining a carriage and footway along the Thames. All other schemes, whether they propose the erection of gingerbread architecture, or an embankment laid down on the river, involve such expenses, destructions, and conversions of the banks from their most natural and valuable purposes and uses, that one has no alternative but to suppose that they must have stolen into the skulls of the proposers by some cracks and fissures, of which the said proposers had no idea.

The proper use of the banks of the Thames, both on the Middlesex and the Surrey side, is the promotion of commerce, either for foreign trade or for domestic supply; and the town and its suburbs are in this way more indebted to the accommodation afforded by the banks of the Thames, than they are to all other causes taken together. The wharfs and other business accommodations along those banks, may not suit those persons who are all for finical prettiness, and care nothing for utility; but the many thousands of London—and altogether they are considerably upwards of twelve hundred times a thousand, would feel the interference with the wharfs in a diminution of all their domestic comforts, and an increase in the whole of their household expenditure. A fantastic line of architectural structures would be no compensation for this, and besides, it would be of no use. Therefore, all the projects which would go to interfere with the accommodations of trade, on the London or left-hand bank of the Thames, are not only impracticable, but would be absurd and mischievous, though they could be carried into effect. The plan of "A Projector" has none of those evils; it would, if carried into effect, not interrupt the London side trade in the smallest iota; and instead of doing any harm to the trade on the Surrey side, and the general navigation on the river, it is highly probable that it would improve both.

The chain arches, too, would be placed in a situation where they would be little liable to injury from the atmosphere, and although a sort of panic against chain bridges has been excited by the speedy decay of the Menai bridge, this makes nothing against properly constructed chains, so sheltered as they must be near the London bank of the Thames. The Menai strait is the severest situation for a chain bridge across that can well be imagined; the land both in Caernarvonshire and in the Isle of Anglesea is high, and forms a sort of funnel at each end: at that part of the strait which the chain bridge is suspended across, the winds are concentrated by this funnel, whether they come from the one direction or the other; and they thunder upon the suspension bridge with all the force of their concentration. In consequence of this, the bridge vibrated very much, even when it was first constructed; and as this vibration tended to loosen the chains upon their bearings, of course the vibration rapidly increased, and part of the structure at last gave way. We must admit, that there were some serious faults in the construction; and it could not well be otherwise. Mr. Telford, though an able engineer in all matters in which he had had experience, yet had no experience in chain bridges, and probably knew little of the principle of them. Indeed, we may just remark in passing, that the proposals for cobbling up Menai bridge, advanced by Mr. Provis, and corroborated by some other engineers of name, are all calculated to increase the central vibration, and consequently to accelerate the destruction of the bridge. On this part of the subject we hope to have something more to say, when our friends shall put us in possession of the data.

The chain arches supporting the roadway up and down the Thames can be subject to none of these contingencies. They lie in the direction of the atmospheric current, whether that current sets upwards or downwards; and as there are few or no atmospheric currents across the Thames, there is nothing to bring the chain arches into a state of vibration. Hence,—if the piers are substantial, and the chains of sufficient strength, and put down in

a proper manner, there is nothing but simple wear to affect this roadway. This is in itself a very important matter; and, taken in conjunction with other circumstances, it bids fair to show that the opening of this roadway will be as perfect as when put up, when such a structure as the Menai bridge shall have cost far more in repairs than the price of the original construction.

We shall take another opportunity, and we hope an early one, for entering more fully into the particulars; and in order the more satisfactorily to do this, we shall endeavour to get at the data from those who are well qualified for furnishing them accurately; and if any prowling thief of projects shall dare to meddle with the matter, or claim any portion of it as his, we shall "find out the data" in his case, and gibbet him Haman height.

REVIEW.

A Practical Treatise on the Manufacture and distribution of Coal-Gas, &c. By Samuel Clegg, Junior, C. E. Weale, 1841.

Gas is in itself a very luminous substance; and Mr. Clegg has done it justice by writing a very luminous treatise on its manufacture, distribution, introduction, and progressive improvement in the lighting up of towns, and manufactories and other buildings. Coal gas is of great interest and value, not merely as a source of nocturnal light, but as a very efficient means in co-operating to preserve the public peace and morals, especially in the crowded neighbourhoods of great cities. The old working oil lamps, stuck upon brackets close to the walls, and few and far between, were at the time of their introduction looked upon as a very great improvement upon no lamps at all; and certainly so they were, for, previous to their coming into use, there were more robberies and murders committed in the streets of London, than upon all the most notorious resorts of highwaymen. Nothing in fact was more common than to find some half dozen of dead bodies in the morning; and as the then authorities had not only no power and no instrument for putting down the enormities, but on the other hand, often shared the spoil when robbery as well as murder was perpetrated, they said nothing about the matter. There was no memorial to the executive, no petition to Parliament, no public excitement created. All went on as a matter of course, just as though these horrible and nightly crimes had been part of the established system of human nature.

We are in the habit of lauding the "good old times;" of regretting that we were not born some centuries ago; and of grumbling at the taxes and imposts which fall so heavily upon us, and make our lives scenes of bitterness, as compared with the merry days and jovial nights of our remote ancestors. But when we come to look at the matter with the eye of philosophy, and to contrast the two epochs upon their real nature and merits, we find that, as is not unusual when we take up praise and censure with all the meaningless monotony of a cuckoo song, we laud the evil and objurgate the good.

If we would calmly look at the moral and intellectual progress of society, in conjunction with the physical accommodations and improvements which have been gradually introduced by men of observation and talent, it is very much to be suspected, that these have far outrun the pulpits in promoting the real welfare of the human race, and that the introducers of gas lights have been much more useful to their fellow men than the propounders of all the new lights which are to be met with in the diurnals of superstition and fanaticism. These last course each other over the face of society, like the shadows of clouds in an autumnal breeze: while the last are mere dark or dirty spots on the face of society, and they are speedily gone, leaving no memorial behind them.

Of coal-gas light, Mr. Clegg is admirably fitted for being the descriptive historian. We may indeed say he has a hereditary qualification and claim to this office—his father having been engaged in the production and management of gas, almost immediately after its first application as a light by Mr. Murdoch. The same light was practically used in France just about the same time, but the advances of its application were much less rapid in that country than in Britain: the agitated state of the French people may in part account for this; but it is also in great part owing to France being less a manufacturing country. On its first introduction, little attention was paid to the purification of coal gas; and the result was, that it was a little offensive in all situations, and highly so in many. Without considering its effects in this state of impurity, it was employed very indiscriminately, not only for lighting streets, manufactories, and the public rooms of houses, but also for shops and sleeping apartments. In the former, the extraneous gases, especially sulphuretted hydrogen, tarnished metallic goods, removed the colours from drapers' wares, and spoiled everything with which it came in contact; and in the latter, besides its offensive smell, it produced headache and other serious complaints. These circumstances led to its purification by means of lime water; and the process has gradually undergone successive improvements, so that coal gas is now obtained in a state of comparative purity. Mr. Clegg, senior, appears to have been the first who applied a regular apparatus for purifying gas, which was erected at the Catholic College of Stonyhurst, in 1807 and 1808. While erecting his apparatus, Mr. Clegg consulted Dr. Henry of Manchester, and that gentleman, in a paper to the Royal Society of 1808, claimed the process as his own. About the same time, another claimant for the whole invention made his appearance. This was Mr. Winsor, who certainly had the merit of procuring the establishment of the first Gas Company in the metropolis; but the original invention, or rather discovery, unquestionably belongs to Mr. Murdoch, though even before him certain amusing experiments had been performed with gas by different parties; and these were considered as imitations of the perpetual fires kept burning, for superstitious purposes, in the West of Asia especially, and the gas which supplied which escaped through fissures of the earth, or was sometimes obtained from fountains of naptha.

These particulars, together with the history of gas-lighting down to 1841, are mentioned by Mr. Clegg in the first section of his volume; but though this section, and indeed all the sections of which the volume consists, are expressed with wonderful clearness, yet the book is a whole, and must be read as such; for quotations would only garble it without affording any adequate instruction. The second section treats of the chemistry of coal gas, and of the other gases which are produced along with it in the process of distilling coal. The chief of these are carburetted and sulphuretted hydrogen, and olefiant gas, which is a compound of oil or resin with chlorine. These products vary in quantity with the nature of the coal, and also with the process used,—that process which affords most olefiant gas being the most valuable. Besides these, there are various other circumstances, such as nitrogen, chlorine, bituminous substances, known under the appellation of coal tar and ammonia, most of which have a highly offensive odour.

Mr. Clegg next gives a short account of the appearance and qualities of the different kinds of coal, with a view of ascertaining the portion of gas that may be produced by each. Cannel coal is the most productive, that of Wigan in Lancashire yielding 542 cubic feet of gas from 84 pounds weight of coal. Scotch Cannel is rather inferior; and then the Newcastle coal, the best Staffordshire and the Welsh follow each other, though some of the Stafford is inferior to the Welsh. The coal which yields most gas is that which burns with the greatest and most lambent flame in the open air; but it does not follow that this is always the best for producing it. On this subject, Mr. Clegg details a number of experiments, showing both the products and the quantity of each product, together with the specific gravities of gas, according to different experiments. Having stated those particulars, our author proceeds to point out the advantages which result from the use of gas as a light. These are of two kinds—economical as to the substance itself, and simple and easy as regards the distribution. In point of economy, gas, even where obtained at the greatest expense, costs one half less than oil lamps or candles; and in point of distribution, it offers facilities which are hardly known in the case of any other substance. It is so light and compressible, and at the same time so elastic, that the cover of a gasometer suffices to force it over very long distances, and through any number of windings; while the chief points to be guarded against, are a little care that the gas is not such as either to corrode the pipes, or to clog them up with coal tar. The situations of the gas works in several houses point out how very difficult it is to get the common unreflecting herd of mankind out of the rut when once they get fairly into it. In supplying houses with water, the higher that the point of supply is situated the distribution is the more easy, upon the common hydrostatic principle that water is heavier than air. With gas the case is quite the reverse; and therefore the lowest situation that can be selected is the best for the gasometer. Instead of this, however, we sometimes meet with these works in the very highest part of the town, even where the carriage of coals for their supply is more expensive; and a practice so opposite to the principles of the case could not have originated except in the grossest ignorance. In consequence of it, we often find the higher parts of a town most brilliantly lighted, while the gas lights are dim and trifling in the low and foggy places, where they are the most needed.

After having discussed all these subjects, which may be said to form an epitome of the history and philosophy of coal gas, Mr. Clegg proceeds to describe the best forms of apparatus for producing, refining, and using it, together with the best modes of working. To the sections explanatory of these points, are appended a number of well-executed plates from working drawings, which greatly increase the value of the book, and cannot fail in being highly useful to all who are engaged in gas manufacture. The retort which is recommended for general purposes, is that which from its section is called a D. The largest size is about 6 feet 3 inches in length, and 1 foot 8 inches in the greatest width, by 1 foot 2 in height. One of these holds 2 cwt. 28lbs. of coal, and the distillation is completed in about six hours. Larger retorts than this are not profitable, because the distillation in them is less perfect; but smaller ones are often used. The D retort possesses this advantage over a cylindrical one, that a thinner stratum of coal can be spread out to a greater breadth; and thus the distillation is more complete and also more rapid, both of which are important considerations in the economy of gas. Very minute directions are given for the construction of retort houses, the setting of the retorts, the receptacle for the coal tar, and all the other parts of the process; but they are too long for being quoted entire, and too full of matter for admitting of abridgement. Indeed, fulness of matter connected with the subject, and the absence of anything extraneous, are the grand characteristics of Mr. Clegg's book.

Our author describes various kinds and forms of retorts, and different modes of using them to the best advantage, some of which are taken from the author's own experience, and partly from other scientific gas manufacturers. In this part of the work, we notice several errors in spelling, especially in the names of Scotch towns, some of which would puzzle a conjurer. Earthen retorts, whether moulded of fire clay, or formed of fire bricks, are examined, and it is stated that large ones are more economical than small. The advantages which they possess over metal, consist in their retaining heat better while the charges are shifted, in the superiority of the coke they produce, and in their durability—they not being so liable to be corroded by the acid gases as retorts made of cast iron. The best material, whether for moulded retorts or for built ovens, is Stourbridge fine clay, the same as is used for melting pots and glass-houses; and these are found to answer best in practice.

Whatever may be the form and composition of the retort, the gas delivered from it is always in an impure state; and therefore purifiers become necessary. The first part of this consists in condensing those products which are gaseous only at a high temperature; and the apparatus made use of for this purpose acts on the principle, if it is not made in the form, of the worm by which spirituous liquors are condensed. The next part of the purifying apparatus is for the removal of those products which are not condensible by low temperature, but must be absorbed by some other substance. Lime is the chief of these; and its main object is to absorb the sulphuretted hydrogen. This lime may be used either as lime water, or as dry: it varies in quantity with the nature of the gas, and also with the mode of operation; and Mr. Clegg mentions that as limestone, the lower oolite and chalk are the principal substances from which it is most advantageously obtained.

The different gas-meters are then described. These are useful appendages to the gas works, both in the station meter, which ascertains the total product of gas sent to the mains from the gas meters, and in the consumers' meters, for ascertaining small quantities supplied to customers for specific purposes. These contrivances let those employed in the works see what quantity is produced in any given time; and consequently the state of the producing apparatus can be discovered from this. The consumers' meters again give them the quantity bargained for regularly at the stipulated times, and in neither too great abundance or deficiency. Gas meters we need hardly describe; for they are large vessels, and abundantly conspicuous; only we may remark that the name is misapplied, inasmuch as these vessels are reservoirs of gas, and have nothing to do with the measuring of the quantity. To the gas meter, there is usually attached a governor for regulating the supply, and this is especially necessary in cases where there is a great charge in the mains after many of the lights are shut off, as is apt to be the case in a town after the shops are closed and the lights extinguished, and the street lights continue burning. If there was not a governor in this case, these lamps would have more than their proper supply, which would tend to corrode the metal of the burners, and also be a great loss of gas to those furnishing the supply.

Some very sensible observations on valves and other individual parts of the apparatus follow, and then the author goes on to treat of street mains, and the method of ascertaining the perfect soundness of the tubes, and forming the joints in the most perfect manner. The distribution of gas through the mains, and the pressure necessary to give it a certain velocity, are stated; but we are inclined to think that on this part of the subject Mr. Clegg adheres too strictly to the theory of the squares. In the motion of all fluids, this theory is faulty when we come beyond a certain velocity, and even within moderate limits it is only an approximation, though a close one. The motion of fluids, and the motive forces by which they are propelled, are a somewhat difficult subject; and experiment must go along with theory in all conclusions respecting it, which aim at perfect accuracy. Burners, by which the light is given, are naturally the final portion of a gas apparatus; but they require no description, except for practical purposes.

The book closes with some account of the secondary products of the distillation of coal for gas. Of these, coke, or the dry and solid residium of the coal, is the first in importance; although, for purposes of great heat, gas coke is inferior to that made in regular coke ovens. Coal tar is the next in value; and so long ago as the year 1665, a German chemist proposed to distil coal for obtaining this tar, as its most valuable product. In 1781, the late Earl of Dundonald, who was equally remarkable for the number and ingenuity of his projects, and the losses which he sustained by them, took out a patent for the production of coal tar, as a substitute for that produced by pine timber. It did not answer, however, and thus coal tar was little used, until it began to be supplied by the gas works as a substance of inferior value. The objection to it was, that timber payed with it had not the durability of that payed with tar from recent pine timber. Coal tar contains abundance of hydrogen gas, but its illuminating powers are not equal to those of native naphtha, produced immediately from the earth. Ammoniacal liquor is another product, though one of more doubtful value, as it is supposed to stimulate the growth of plants, by affording a peculiar kind of nourishment to them; but as the food of plants is a very undeterminate matter, or rather a matter respecting which nothing can be inferred from the principles of ordinary chemistry, the value of this product is very obscure and doubtful. The other secondary products are all injurious to the gas, and not useful for any other purpose.

Such is a brief outline of the leading contents of Mr. Clegg's work; and from them, as well as from the style in which it is got up, it fully merits the encomiums which we have bestowed upon it.

INSTITUTION OF CIVIL ENGINEERS.

It gives us great pleasure to mention, as an established fact, and an act of justice which must be gratifying to all parties, that James Walker, Esq., the amiable and talented President of this Institution, is to be hanged—in effigy, in the theatre of the Institution, as soon as the council and members have found out a first-rate artist to finish him.

INSTITUTION OF CIVIL ENGINEERS.

OBSERVATIONS ON THE EFFECT OF WIND ON THE SUSPENSION BRIDGE OVER THE MENAI STRAIT, MORE ESPECIALLY WITH REFERENCE TO THE INJURIES WHICH ITS ROADWAYS SUSTAINED DURING THE STORM OF JANUARY 1839." BY W. A. PROVIS, M. INST. C.E.

In the month of December 1825, when the original construction of the bridge was nearly completed, several severe gales occurred, and considerable motion was observed, both in the main chains and in the platform of the carriage ways. It appeared that the chains were not acted upon simultaneously, nor with equal intensity; it was believed, therefore, that if they were attached to each other, and retained in parallel planes, the total amount of movement would be diminished.

On the 30th of January, and on the 6th of February, 1826, some heavy gales again caused considerable motion of the chains and roadway, breaking several of the vertical suspending rods, and of the iron bearers of the platform.

These bearers were constructed of wrought-iron bars, overlapping each other, and bolted together, with the ends of the suspending rods between them, for the purpose of giving stiffness to the structure. The flooring planks were bolted to the bearers, and notched to fit closely round the suspending rods, which were thereby held almost immoveably in the platform.

It was observed, that the character of the motion of the platform was not that of simple undulation, as had been anticipated, but the movement of the undulatory wave was oblique, both with respect to the lines of the bearers, and to the general direction of the bridge. It appeared, that when the summit of the wave was at a given point on the windward side, it was not collateral with it on the leeward side, but, in relation to the flow of the wave, considerably behind it, and forming a diagonal line of wave across the platform.

The tendency of this undulation was, therefore, to bend the bearers into a form produced by the oblique intersection of a vertical plane with the surface of the moving wave. The bearers were not calculated to resist a strain of this nature: they therefore were fractured generally through the eyes on each side of the centre foot-path, at the point of junction with the suspending rods, which being bent backwards and forwards where they were held fast at the surface of the roadway, were in many instances wrenched asunder also.

The means adopted for repairing these injuries, and for preventing the recurrence of them, were, placing a stirrup, with a broad sole, beneath each of the fractured bearers, attaching it by an eye to the suspending rod, cutting away the planking for an inch around the rods, and at the same time bolting, transversely, to the underside of the roadway, an oak plank, fifteen feet long, between each two bearers, for the purpose of giving to the platform a greater degree of stiffness, combined with elasticity, than it previously possessed. The four lines of main chains were also connected by wrought-iron bolts passing through the joint plates, and traversing hollow cast-iron distance pieces, placed horizontally between the chains.

The effects of these alterations were so beneficial, that little or no injury occurred for nearly ten years. On the 23d of January, 1836, a more than usually severe gale caused violent undulation of the platform, and broke several rods. There can be little doubt that ten years' constant friction, combined with the shrinking of the timber, had relaxed the stiffness of the platform, and permitted an increased degree of undulation. The gate-keeper described the extreme amount of rise and fall of the roadway in a heavy gale to be not less than sixteen feet; the greatest amount of motion being about half way between the pyramids and the centre of the bridge.

In consequence of the injuries sustained during this gale, the author and Mr. Rhodes were instructed to give in a report upon the state of the bridge, and on any repairs or additions which might appear desirable.

The result of the examination was satisfactory; the whole of the masonry, the main chains, their attachments to the rock, the rollers and iron-work upon the pyramids, and all the principal parts of the bridge, were as perfect as when first constructed; it was, however, recommended, that "a greater degree of rigidity should be given to the roadways, so that they should not bend so easily under vertical pressure."

The bridge remained in the same state until the hurricane of the 6th and 7th of January, 1839; during the night of the 6th, all approach to the bridge was impracticable; the bridge-keeper, however, ascertained that the roadways were partially destroyed; and he in consequence traversed the strait in a boat in time to prevent the down mail from London driving on to the bridge.

When the day broke, it was found that the centre footpath alone

remained entire, while both the carriage ways were fractured in several places. The suspending rods appeared to have suffered the greatest amount of injury; out of the total number of 444, rather more than one-third were torn asunder; one piece, 175 feet long, of the N.E. carriage way, was hanging down and flapping in the wind; much of the parapet railing was broken away; the ties and distance pieces between the main chains were destroyed; the chains had resisted well in spite of the violent oscillation they had been subjected to, to such an extent, as to beat them together and strike the heads off bolts of three inches diameter.

Means were immediately adopted for restoring the roadways; and so rapidly was this effected, that in five days carrriages and horses passed over, while foot passengers were not at any time prevented from crossing.

The account of the restoration of the bridge, communicated by Mr. Maude to the Institution, is then alluded to.

The substance of the report of the author to the Commissioners of Her Majesty's Woods is then given, and a review of the proposals made by Mr. Comms, Colonel Pasley, and others, relative to the restoration.

The opinion of Colonel Pasley, "that all the injuries which have occurred to the roadways of Suspension Bridges must have been caused by the violent action of the wind from below," is then examined, and reasons given for the author's dissent from that opinion.

The action of the wind upon the Conway and Hammersmith Bridges, is next examined; and from the amount of oscillation observed in all suspension bridges, the conclusion is arrived at, that winds act strongly and prejudicially on the fronts as well as on the horizontal surfaces of the platforms of suspension bridges, and that the effect of winds is modified and varied by the nature of the country, and the local circumstances connected with each individual bridge. Although differing in opinion with Colonel Pasley as to the general cause of injury to suspension bridges, the author agrees with him in the propriety of giving increased longitudinal rigidity to their platforms, to prevent or to restrict undulation. He advised its adoption in 1836, and applied his plan of stiffening by beams, in 1839. He preferred beams to trussed framing, on account of the facility with which the former could be increased in number, to obtain any requisite degree of stiffness, and because he feared that trussed frames could not always be kept firmly in their true vertical positions.

A drawing showing the injuries sustained by the platform during the hurricane of 1839, accompanied the communication.

Mr. Cowper was of opinion, that the real cause of injury to suspension bridges was the vibration of the chains and roadway. The whole suspended part, when acted upon by the wind, became in some measure a pendulum, and if the gusts of wind were to recur at measured intervals, according either with the vibration of the pendulum, or with any multiples of it, such an amount of oscillation would ensue as must destroy the structure. He illustrated this proposition by a model with chains of different curves, and at the same time pointed out the efficiency of slight brace chains in checking the vibration.

Mr. Brunel agreed with Mr. Cowper in his opinion of the cause of injury to bridges, and with the propriety of applying brace chains, for preventing the vibration. He then alluded to the introduction of lateral braces in the bridge designed by Mr. Brunel, Sen. for the Isle of Bourbon. He had been at the Menai Bridge during a severe storm, and had particularly noticed the vibration of the chains, with the accompanying undulation of the platform. The force of the wind was not apparently from beneath; it appeared to act altogether laterally. The chains were too high above the roadway; their vibration commenced before the platform moved: the unequal lengths of the suspension rods then caused the undulating motion. His attention had latterly been much given to the subject on account of the Clifton Suspension Bridge, now erecting under his direction. The span would be seven hundred feet, and the height above the water about two hundred feet. He intended to apply the system of brace chains at a small angle to check vibration. To two fixed points in the face of one pyramid would be attached two chains, each describing a curve horizontally beneath the platform, touching respectively the opposite sides of the centre of the bridge, and thence extending to similar points on the other pyramid: there they were attached to two levers, the ends of which were connected with a counter balance of about four tons weight appended to each; these weights would hold the chains sufficiently extended to enable them to resist the lateral action of the strongest winds without their being so rigid as to endanger any part of the structure. By this contrivance the platform would be kept firm, which was the chief point to be attained.

In all suspension bridges the roadways had been made too flexible, and the slightest force was sufficient to cause vibration and undulation. The platform of the Clifton Bridge would have beneath it a complete system of trough-shaped triangular bracing, which would render it quite stiff. He was an advocate for bringing the main chains down to the platform, as at Hammersmith Bridge, and for attaching the bearers to the chains at two points only; when they were suspended by four rods, it not unfrequently happened that the whole weight of a passing load was thrown upon the centre suspension rods, and the extremities of the bearers were lifted up and relieved from all pressure. The extent of the expansion and contraction of the chains was a point of importance. In the Menai Bridge, the main chains on a summer day would be as much as sixteen inches longer than in a winter's night. At the Clifton Bridge the difference under similar circumstances would be about twenty inches. The whole expansion of the back chain beyond the pyramids must be thrown into the suspended part. He would prefer having only one chain on each side of the bridge, and that chain much stronger than is usually adopted, but in deference to public opinion he had put two; he believed that they rarely expanded equally, and hence an unequal distribution of the weight of the roadways upon the suspension rods occurred. A rigid platform would in some degree prevent this, but he had endeavoured to lessen the effects of unequal expansion by arranging a stirrup at the top of each suspending rod, so as to hold equally at all times upon both the chains, and thus cause each to sustain its proportion of the load.

Mr. Seaward had never seen the force of wind exerted at regular intervals, as Mr. Cowper had supposed; if the gusts were repeated at such intervals, no suspension bridge, nor any elevated shaft or chimney in masonry, could resist them.

Mr. Rendel believed that the errors committed in the construction of suspension bridges had principally arisen from engineers theorizing too much on the properties of the catenary curve, without attending sufficiently to the practical effects of wind in the peculiar localities in which the bridges were placed. He could not agree with Mr. Cowper in his view of the intermittent action of the wind, or the vibrating of the chains. Observation had led him to conclude that, in the positions in which suspension bridges were usually placed, the action of the wind was not uniform; for instance, it would act at the same moment on the upper side of the end of the roadway, and on the lower side at the other end. In this case, unless the platform possessed a certain degree of rigidity, undulation was induced and oscillation ensued. Braces and stays would not counteract this—nothing but a construction of platform, which made it in itself rigid by some mode of trussing, could withstand this kind of action. He agreed with Mr. Brunel in his idea of reducing the number of the suspending chains. At the Montrose Bridge, which was 432 feet span, he had endeavoured to avoid all complexity of contrivances by adopting a complete system of vertical diagonal trussing, which was ten feet deep—five feet above, and five feet below the platform—so as to insure rigidity, and to produce that solidity which was essential for preventing undulation and oscillation.

Mr. Cowper reverted to the motion which he had found to be so easily produced by repeatedly exerting a small force at measured intervals against the main chains of the Hammersmith Bridge. He conceived that if the chain oscillated, the roadway must oscillate also.

Mr. Rendel contended that the motion produced by the impulses communicated by Mr. Cowper to the chain resolved itself into undulation, and not oscillation. He could not understand the advantages of the trussing adopted at the Hammersmith Bridge: it appeared to him that its tendency was, on the passage of a heavy weight, to relieve four out of five of the suspending rods from their due proportion of the load, and to throw it upon the fifth rod. His object in the construction of the framing of such platforms had always been to spread the load quite equally, and rendering it rigid by means of vertical trussed framing, to prevent the undulation which was the primary cause of oscillation. He would distinguish clearly between the two motions, and say, that undulation was motion in the direct line of the platform, and that oscillation was a motion at right angles with it. Vibration was identical with undulatory action.

Mr. Donkin conceived that a good system of trussed framing could alone prevent undulation or oscillation; if the framing were placed vertically, its tendency would be to prevent undulation; if placed horizontally, to prevent oscillation; now, as Mr. Rendel had given it as his opinion, that the latter action resulted from the former, the system of trussing adopted by him at the Montrose Bridge would appear calculated to obtain the desired end. A slight exertion of force would produce a perceptible undulation, and a certain degree of vibration would result from the natural elasticity of the materials.

Mr. Seaward remarked, that the degree of oscillation would appear to depend in some measure upon the distance at which the platform was suspended beneath the chains, and upon the distance between the points of suspension of the main chains; if the platform was rigidly held at the extremities, the motion would be vibratory, and not amounting to undulation.

BRIDGES, ANCIENT AND MODERN.

PERUVIAN BRIDGES.—"Over the river Desaguadero is still remaining the bridge of rushes, invented by Capac Yupanqui, the fifth Ynca, for transporting his army to the other side, in order to conquer the provinces of Collasuyo. The Desaguadero is here between eighty and a hundred yards in breadth, flowing with a very impetuous current, under a smooth, and as it were, a sleeping surface. The Ynca, to overcome this difficulty, ordered four very large cables to be made of a kind of grass which covers the lofty heaths and mountains of that country, and called by the Indians, Ichu; and these cables were the foundation of the whole structure. Two of these being laid across the water, fascines of dry juncia and tortora, species of rushes, were fastened together, and laid across them. On these the two other cables were laid, and again covered with the other fascines securely fastened, but smaller than the first, and arranged in such a manner as to form a level surface; and by this means he procured a safe passage to his army. This bridge, which is about five yards in breadth, and one and a half above the surface of the water, is carefully repaired, or rebuilt, every six months, by the neighbouring provinces, in pursuance of a law made by that Ynca, and since often confirmed by the kings of Spain, on account of its prodigious use; it being the channel of intercourse between those provinces separated by the Desaguadero.

"When the rivers are too deep to be forded, bridges are made at the most frequented places. Of these there are two kinds besides those made of stone, which are very few: the former of wood, which are most common; and the latter of bujucos. With regard to the first, they choose a place where the river is very narrow, and has on each side high rocks. They consist of only four long beams laid close together over the precipice, and form a path about a yard and a half in breadth, being just sufficient for a man to pass over on horseback; and custom has rendered these bridges so natural to them, that they pass them without any apprehension. The second, or those formed of bujucos, are only used where the breadth of the river will not admit of any beams to be laid across. In the construction of these, several bujucos are twisted together, so as to form a kind of large cable of the length required. Six of these are carried from one side of the river to the other, two of which are considerably higher than the other four. On the latter are laid sticks in a transverse direction, and over these branches of trees as a flooring; the former are fastened to the four which form the bridge, and by that means serve as rails for the security of the passenger, who would otherwise be in no small danger from the continual oscillation. The bujuco bridges in this country are only for men, the mules swim over the rivers; in order to which, when their loading is taken off, they are driven into the water near half a league above the bridge, that they may reach the opposite shore near it, the rapidity of the stream carrying them so great a distance. In the mean time, the Indians carry over the loading on their shoulders. On some rivers of Peru there are bujuco bridges so large, that droves of loaded mules pass over them; particularly the river Apurimac, which is the thoroughfare of all the commerce carried on between Lima, Cusco, La Plata, and other parts to the southward.

"Some rivers, instead of a bujuco bridge, are passed by means of a tarabita; as is the case with regard to that of Alchipichi. This machine serves not only to carry over persons and loads, but also the beasts themselves; the rapidity of the stream, and the monstrous stones continually rolling along it, rendering it impracticable for them to swim over.

"The tarabita is only a single rope made of bujuco, or thongs of an ox's hide, and consisting of several strands, and about six or eight inches in thickness. This rope is extended from one side of the river to the other, and fastened on each bank to strong posts. On one side is a kind of wheel, or winch, to straighten or slacken the tarabita to the degree required. From the tarabita hangs a kind of leathern hammock, capable of holding a man; and is suspended by a clue at each end. A rope is also fastened to either clue, and extended to each side of the river, for drawing the hammock to the side intended. A push at its first setting off, sends it quickly to the other side.

"For carrying over the mules, two tarabitas are necessary, one for each side of the river, and the ropes are much thicker and slacker. On this rope is only one clue, which is of wood, and by which the beast is suspended, being secured with girths round the belly, neck, and legs. When this is performed, the creature is shoved off, and immediately landed on the opposite side. Such as are accustomed to be carried over in this manner, never make the least motion, and even come of themselves to have the girths fastened round them; but it is with great difficulty they are at first brought to suffer the girths to be put round their bodies, and when they find themselves suspended, kick and fling, during their short passage, in a most terrible manner. The river of Alchipichi may well excite terror in a young traveller, being between thirty and forty fathoms from shore to shore; and its perpendicular height, above the surface of the water, twenty-five fathoms."—*Don Ulloa.*

CHINESE BRIDGES.—"The stone bridges are commonly built like ours, on large piers of stone capable of resisting the rapidity of the stream, and sustaining the weight of the arches, wide enough for the passage of large vessels. They are exceedingly numerous, and the Emperor spares no expence when the public good requires them to be built.

"Of these, there is one very remarkable at Foutcheou-fou, capital of Tou-kien. The river over which it is built is half a league in breadth: it is sometimes divided into small arms, and sometimes separated by small islands; these are united in joining the islands by bridges, which make altogether eight furlongs or Chinese lys and 76 toises. The principal of these has alone above one hundred arches built of white stone, with bannisters on each side handsomely carved, upon which, at the distance of every ten feet, are placed square pilasters, whose bases are very large, resembling hollow barks.

"But that which excels all the rest is at Suentcheou-fou, built over the point of an arm of the sea, without which the passage would be sometimes dangerous, even in a boat. It is 2500 Chinese feet in length and 20 in breadth; it is supported by 252 strong piers, 126 on each side. All the stones are of the same bigness, as well those which are laid from pier to pier, as those which are laid crosswise, insomuch that it is difficult to comprehend how stones of such an enormous size should be placed in that regular manner, or even raised on the high piers on which they lie. After this, there is nothing of the kind worth mentioning."—*Duhalde.*

The only conclusion to be drawn from the foregoing description of this work, which excels all the rest, is, that two rows of large stones or piers, (each row consisting of 126,) have been set up across the shallow mouth of a river or arm of the sea: that, along the top of these, other long stones have been laid horizontally, like wooden beams: and lastly, that long stones have been laid crosswise upon those longitudinal beams, in the manner of joists in carpentry, or more probably close together, composing a compacted bed or roadway. By dividing 2500, the total length in Chinese feet, by 127, the number of openings, it gives nearly 20 feet between centre and centre of the piers, so that after the thickness of the pier is taken away from the 20 feet, a moderate opening is left for the lintel to cover. The dimensions crosswise correspond with the description as to the stones being of the same size, (at least at to length): for the breadth of the bridge is said to be 20 feet, and taking away the thickness of the two longitudinal beams, leaves the dimensions of the opening to be covered by the stones lying crosswise. It is therefore to the carrying from the quarry and raising stones of this magnitude, that the praise of ingenuity must be attributed; there being nothing else in the mode of construction which has a claim to refined science, or great progress in the mechanical arts. The danger to boats passing, must, no doubt, have arisen from the shallowness of the water, and the frequency and violence of the surfs.

From the following relation, extracted from the same work, there is reason to expect correct information. It is entitled, "An account of the Journey of the Fathers Boures, Fontenay, Gorbillou Le Compte, and Vesdelore, from the port of Ning Po to Pekin, with a very exact and particular description of all the places through which they passed, in the provinces of Tche-kiang, Kiang-nan, Chan-tong, and Pe-tcheli.

"It is in this agreeable place that the city of Chao King has its situation. In the streets are a great number of canals, which give occasion for such a great number of bridges. They are very high, and have generally but one arch, which is so slightly built towards the top, that carriages never pass over them, which makes a great number of porters necessary. They pass over these bridges by a kind of stairs, of very easy ascent, and whose steps are not more than three inches in thickness. There are other sorts of bridges, made of stones 18 feet long, laid upon piles in the manner of planks. There are many of these over the great canal very handsomely built."

Again, "About four leagues from Hang-tcheou we crossed a village called Tan-si. It is built on both sides of the canal, on which are also two quays, about 400 or 500 geometrical paces in length. They are formed of the same freestone which lines the sides of the canal. There are stairs for the conveniency of every house, which are much better built, and more uniform than those in the city. In the midst of the village is a fine bridge of seven large arches; that in the middle is 45 French feet wide; the rest diminish in proportion to the descent of the bridge. There are two or three great bridges of one arch only.

"We crossed a great village or country town, called Ovan Kiang King, of large extent. One part communicates with the other by means of a bridge of three great arches, very curiously built; the middle arch is 45 French feet wide and 20 feet high."

Of these arches, which are here termed large and great, we find the

span to be only 45 feet; an extent which, in Europe, would not be honoured with those appellations.

We have also heard of a bridge over a river named Laffrany in China, which joins two mountains together, said to be of one arch 600 feet span, and 750 feet in height; but having no distinct authority for this, and its being so very unlike to those described in Duhalde's work, we mention it merely as a matter deserving of more inquiry.

But it is of real importance to notice the description given by Mr. Barrow of the mode in which some of the arches in China are constructed. "Each stone, from five to ten feet in length, is cut so as to form the segment of the arch, and in such cases there is no key stone; ribs of wood fitted to the convexity of the arch, are bolted through the stones by iron bars fixed into the solid part of the bridge; sometimes they are without wood, and the curved stones are mortised into long transverse blocks of stone."

THE HOLYHEAD ROAD.

The Menai and Conway Suspension Bridges formed only a part of the works on a line of road which altogether presented the most striking proofs of Telford's skill in nearly every branch of his profession,—and which at length exhibited so high a degree of perfection in all its details, that it came to be considered "the best thoroughfare on the surface of the globe." This was the Holyhead Road.

Up to the year 1815 this road, although very much frequented, remained in a wretchedly imperfect state; nor were the other arrangements for communication between England and Ireland in a more forward condition. The sailing packets of that day were often beating about for several days on the short passage of twenty leagues between Dublin and Holyhead, and then the passengers were landed on a mass of rugged rocks on the Welsh side, and then, after travelling over twenty-four miles of road in the isle of Anglesea, of so miserable a description as to be now scarcely credible, had to cross the dangerous ferry of the Menai in boats as they best might—wind and tide permitting. After passing this peril, the roads through North Wales were in most parts exceedingly narrow and rugged, often over steep mountains and by the side of precipices, from which the wayfarer was not protected by a parapet; and even during the remainder of the journey, although through the richest parts of England, the means of transit were in anything but first-rate order. Sir John Rennie, who was employed to remedy some of these inconveniences, introduced several essential improvements in the packet stations, and other matters connected with the sea passage, but it was the task of Telford to bring the *roads* into a proper state, as well as, after Rennie's death, to complete the packet-station arrangements commenced by him. In 1811 Telford made a report to the Treasury as to the line of road to be adopted. He wished, if possible, to set out a direct line through North Wales, but found that quite impracticable, from the mountainous character of the country; he adhered therefore to a line which had been projected several years before, which passed by Capel Cerrig and the vale of the river Agwen to Bangor, and effected a saving of several miles. A multitude of minor improvements, in the aggregate of great importance, he found to be practicable, and recommended accordingly, and the old road through the isle of Anglesea he set aside altogether, and laid out an entirely new line. For four years after this report was made, nothing was done to effect its objects; until in 1815, the matter was taken up by Sir Henry Parnell, to whose subsequent exertions and unwearied activity in and out of parliament, the Holyhead Road owed much of its final excellence. In consequence of his interference, in a short time liberal grants of the public money were made by the House of Commons, and a body of Commissioners appointed, under whose control the necessary contracts were entered into, and payments made, and by whom the requisite officers were appointed. The Commissioners were responsible to Parliament alone, to whom they were to make annual reports of their proceedings. By them Telford was appointed Chief Engineer of the projected works.

Contracts were immediately opened, and in the course of the ensuing four years great progress was perceptible. In North Wales, the road making was conducted in the same manner as on the Carlisle and Glasgow road, also superintended by Telford, except that the masonry of the bridge walls and similar erections was not composed of sandstone, but of schistus, or slate-rubble. The largest bridges were of iron, but with stone abutments. In order to ensure a durable road, the bottom was regularly paved with schistus, on edge,—on which was placed a layer of broken stone or "top metal," five or seven inches thick, composed of basalt, porphyry, limestone, or grauwacke, to procure which was sometimes a most difficult task, most of the stone in North Wales being schistus, and consequently of too soft a nature for the purpose. Over all was laid a thin coat of gravel, that the surface, by binding, might become of a hard and smooth consistence. This whole road, over a rugged and mountainous district, along rocky precipices, and across wide inlets of the sea, on which the mails and other coaches now travel at the rate of ten miles an hour, proved a most arduous undertaking, and occupied fifteen years of unremitting labour on the part of all concerned, amongst whom the Chief Engineer had by no means the lightest task.

The greatest operations were the embankments, one across an estuary near Holyhead, called Stanley Sands, and the other at the approach to the Conway Bridge. The former of these is 1300 yards long, and 16 feet in height; the top is 34 feet wide, and the base 114 feet. Both sides of this huge mound are coated with rubble-stones, which simple precaution has been found effectually to protect the whole fabric from the attacks of the strongest storms. By great good fortune, a rocky bottom was discovered for the foundation of the tidal bridge which it was necessary to erect for the passage of the waters, so that the entire structure is of unimpeachable solidity. The other embankment, at Conway Bridge, is 666 yards in length, but of much greater height, being no less than 54 feet. This causes the breadth at the base to be 300 feet, although at the top it is only 30. The tide here, which flows to about 10 miles above the works, is so strong that on one occasion it carried the whole embankment, so far as it had been completed, clear away from the very foundation. The works, however, were resumed, and the exterior having been protected by a rubble coating, no signs of its giving way have ever since been perceived.

Among the other great improvements on this part of the line may be noticed the road along the stupendous sides of Penmaen Mawr, where formerly the rough and narrow pass was undefended by a parapet, and the traveller was every moment liable to fall over perpendicular precipices of immense height. All these inconveniences are now remedied; while another hill of the same character, Sychnant, 543 feet above the level of the sea, has been wholly avoided by the new line. Altogether, the road through North Wales, notwithstanding the great and almost insurmountable difficulties it presented, has been rendered as safe, smooth, and easily-traversable (except with regard to some few hills) as many roads in the flattest and most populous parts of England.

Between Shrewsbury and London difficulties of a different nature had to be encountered. In this distance there were seventeen different sets of road-trustees, each of which had its own surveyor, and each of which was required to give its consent to the carrying out of any improvement, before a contract could be entered into. It is needless to say that under this state of things, little progress could be made; but at length the Parliamentary Commissioners obtained a new act, in pursuance of which they were enabled to levy an "improvement toll" not exceeding half of that payable to the trustees, and to assume other powers, independent of those functionaries. This done, comparatively few difficulties remained, but in a few years, by unremitting exertions, the Holyhead Road became what it now is,—the very model of a turnpike road. The Commissioners, by virtue of the powers delegated to them by the Acts of Parliament, retained the roads in their own hands for two years after the completion of the improvements,—a highly necessary measure, since very much depends on the manner in which the repairs are conducted, after the first starting off on a new line. As after this period they generally fell into the hands of Mr. M'Adam, it is needless to say that the improvements carried into effect by Telford ran no risk of being suffered to fall into decay, and were as safe from spoliation for want of skill and attention as if they still remained under his own superintendence.

The Holyhead Road was the last great work of the kind executed by Telford, but a considerable portion of his time, during the later periods of his professional career, was occupied in the making of elaborate and minute surveys, under the direction of the Post Office, and at the expense of the public, of several of the principal lines of mail-coach road, with a view, by shortening and improving them, when it could be done, to expedite the delivery of letters and newspapers, in accordance with the "keep moving" spirit of the age. Amongst these, was the great road through South Wales, and also the important line from Liverpool to the junction with the Holyhead Road between Birmingham and Coventry. The whole line of the Great North Road, from the Metropolis to Edinburgh, was also surveyed with the same views, the result being the recommendation of a diversion from the old line, by which the distance would be reduced from 390 miles to little more than 360, so as to lessen the time of communication between the two capitals by no less than *at least* three hours!

Telford sums up the result of his labours in road making with a natural complacency. "The perfected roads having justified a corresponding improvement of wheel-carriages," he observes, "a rapid intercourse was established, first in mail-coaches, and eventually in vehicles of all kinds, until the usual rate of travelling had increased from five or six miles, to

nine or ten miles per hour." Ten miles per hour! just half a common, one-third of a respectable, and one-fourth of a first-rate railway speed!—*Mech. Mag.*

EXPORTATION OF MACHINES.

[As this is a subject of very great importance, and of general interest, we propose (with the kind permission of Mr. Weale, the publisher,) to make some rather copious extracts from the late excellent treatise on the subject by Mr. Grenville Withers, intitled "Considerations in favour of the repeal of the law which prohibits the Exportation of Machinery."]

The present moment seems favourable to the discussion of a subject which concerns, in no small degree, the interests of the principal branches of our manufactures: I refer to the law which forbids the exportation of machinery.

There was a time, not long since, when it required some courage to argue against a law, which was deemed, by most of us, to be the sole guarantee of British manufacturers; to lock up, if I may so speak, for their especial use and benefit, the inventive genius of the land; to place them infinitely above the reach of foreign competition, and so secure to them the universal monopoly of trade.

The execution of a law so important was necessarily sought, and believed to be fully provided for, by the enactment of felonious inflictions—those who imposed them forgetting that pains and penalties, by increasing the perils of illicit commerce, increase its profits also, and that such barriers become more easy to clear in proportion as they are higher. Experience has long since proved the inadequacy of such means, as well as the folly of attempting to confine, within the limits of our territory, processes and inventions in the mechanic arts, which other countries have learned to appreciate, and which they are determined to obtain, at whatever cost. Convinced of these facts, is it not strange, is it not impolitic, to persist in depriving ourselves of the profits of a lucrative branch of export trade?

We have suffered ourselves to be led away from larger considerations of a sound economy, in pursuit of measures which are now working greatly to our disadvantage. We expected, by a selfish system of interdiction, to arrest the progress of manufactures on the continent, and thus to remain sole possessors of practical mechanics. In adopting a narrow policy, not entirely free, perhaps, from hostile feelings excited by national antipathies, we forgot to measure its consequences, and we now find that our own interests are involved by it.

Happily, at length, if we have not outlived our liking for such anti-social systems, we are, at least, beginning to see through their fallacy, and to feel that they are injurious only to ourselves. * *

At no period, since the existence of the law, has it been watched with so much jealousy, or enforced with so much rigour, as during the last five-and-twenty years. The general peace of 1815 released us from a struggle which had been a means of developing the extraordinary capabilities, and scarcely exhaustible resources, of industry and commerce. Our improvements in practical science, our miraculous inventions in the mechanic arts, and the vast application of them, as a moral and physical moving power, to the uses of civilization, had lifted us to the summit of political greatness. But while we ascribed to them all our successes and all our strength, yet, with a contradiction too common in all human affairs, we sought to paralyze their action by rendering absolute an arbitrary law, evidently subversive of the first principles of political economy.

An incongruity so manifest has not, however, been suffered to obtain unmolested. It has often been pointed out, and strongly censured, by all our most eminent economists. But the voice of reason has hitherto failed to convince many honourable, but prejudiced minds. An alarm has been raised whenever the subject has been brought before Parliament. From honest motives, no doubt, but unquestionably mistaken views, manufacturers have invariably opposed a return to a more liberal policy. They have caballed to trouble the consciences of our legislators, and, by partial statements, and erroneous calculations, they have too well succeeded in attaching, to the abolition of the law, an exaggerated responsibility. *

The restrictive system is now working in France, where it is carried out to its utmost limits: and what is the result? The country is poverty-stricken, and so it must remain as long as its industry depends for its existence on prohibitory duties—taxes levied upon internal consumption. The agricultural interests of the whole empire are laid under contribution, and the liberty of the subject sacrificed by odious regulations of the fiscal executive, in support of an over-nursed profitless trade. With a population of thirty-five millions; with a public debt much inferior to our own; a land of plenty, and cheap labour, producing corn, and wine, and oil; with mines of coal and iron, a superb climate, noble rivers, and her shores washed by two seas; with all these rich materials, there is neither capital nor spirit in the country to undertake and complete any great commercial enterprise, unaided by Government loans or foreign stock-jobbers. There is not a single line of railway of any importance; the internal communications are a disgrace to a people boasting so loudly of its civilization. The carriage of the raw material and merchandise by the ill-constructed and worse conducted canals, is a sluggish and an expensive operation, grievously felt by the consumer. Coals, iron, and wearing apparel, are exorbitantly dear, compared with English prices. * *

What an agreeable contrast to this sickly picture presents itself in the growing prosperity of manufacturers in Switzerland! Hemmed in on all sides by unrelenting custom-house barriers; with the expense of an enormous land carriage on the raw material of cotton; with machinery, repairs, lighting, and fuel, 50 per cent. dearer than in England; absolutely without protecting duties, and left entirely to their own resources; still they hold their own against the most powerful and active competition.

We complain with a bad grace of the prohibitory measures adopted by some States for the protection of their manufactures and commerce. We are beginning to be sincere in these matters, because we are suffering from them; but let us bear in mind, that if not the inventors of the system, we have at least the credit of giving it wider limits and a more positive application. Briavoine, *De l'Industrie en Belgique*, fully expresses the opinions and feelings prevalent on the continent, on the subject of our monopolizing spirit, and the inconsistency of doctrines of free trade with the prohibitory practice connected with the non-exportation of our machinery.

He says, "Of late years frequent mention is made of the return of the English to a principle of free trade, of the examples which they give, and which it is necessary to follow; but there is one remark which has been forgotten: England is fully aware of her superiority in the mechanic arts. By the enormous development which those arts have taken in her hands, she has established the basis of every branch of industry, and obtained the key to every species of manufacture. She knows, so long as she preserves over other countries, her rivals, the start which she has taken on the high road of perfection and discovery, she can, without risk to herself, hold out the most complete reciprocity, and preach up the utility of exchange.

"England offers us terms of reciprocity, it is true; but let us never forget that she offers them with one remarkable exception—*machines.*"

To prohibit the exportation of any kinds of machinery, an article of general manufacture all over Europe, and an article more especially whose intrinsic value is so prodigiously augmented by human labour; I say such an interdiction is really too bad. Besides the enormous loss of our industrious population, there is something so politically shabby in the attempt to hinder foreigners from weaving a piece of calico by what we choose to call the English process, that I am at a loss to find terms sufficiently strong wherewith to qualify the utter meanness of our conduct. * * * * *

The argument used in favour of a law so objectionable, so contrary to the spirit of the times in which we live, is briefly this; "If, with the advantages of low-priced labour, foreign manufacturers possessed our improved machinery, they would drive us out of third markets, and ruin our export trade."

If our ability to compete with foreign manufacturers depended upon the secret of our inventions and the superiority of our machinery, our exports must long since have been confined to our own colonies; because it is an indisputable fact, easy of proof, that all our patent inventions and improved machines, belonging to every branch of manufacture, are as well known to foreign manufacturers as they are to our own. It is equally notorious that every improvement in machinery is smuggled out of the country as soon as it is made, bidding defiance to detection. A few years ago, whole ship loads of machinery used to be smuggled away; but that commerce is now confined to new inventions, got out to serve as models to the foreign machine maker. Machines of every description, upon the newest principle, equal in quality, or very nearly so, to the best Manchester make, can be purchased, in any quantities, in France, Belgium, Germany, and Switzerland, at prices varying from 10 to 40 per cent. above our own.

It is alleged that foreign made machines are not so good as similar ones constructed in this country. This was true, with respect to some kinds of machinery, five, nay, three years ago, and might perhaps have been so still, if the law had been as severely interpreted in its application to improved tools, and our ablest artisans, as it has been with regard to some kinds of machinery of much less importance. The law and the practice in this case have been most contradictory. The law peremptorily forbids the exportation of all kinds of machinery employed in manufactures, as well as tools of a certain description; but the practice of the Board of Trade has been to allow the exportation of all tools, and of several machines used as preparers in the above manufactures. The granting of

...es for the exportation of machinery has given rise to abuse—has ...ded another cover to smuggling, by which means many of our most valuable improvements have been carried away. The repeal, in 1824, of that part of the law which forbade the emigration of workmen, upset all consistency, and held out stronger inducements than ever to foreigners to become machine makers. It is deeply to be regretted that the eminent statesman then at the head of the commercial department was not permitted to work out his own enlarged views and profound conceptions of the political economy due to a great empire.

It is idle to talk of the superiority of our machinery, since our best tools, models, and artisans, have left the country. At present there are, in various parts of the continent, large establishments for making machines, furnished with all our most valuable tools, and directed by our cleverest practical mechanicians. A new stimulus has been given to this branch of trade on the continent, within the last seven years, from no other cause than the very great improvements and discoveries which men have effected in the machinery for making machines. Those beautiful engines called tools, most of them self-acting, have done away with the chief obstacles to machine-making abroad. One good tool supplies the place of twenty good workmen; and a man taken from the plough may, without much pains, and in a few days, be converted into an effective mechanic.

Belgium has become our successful rival. The machine-making establishments are all of them on the largest scale. Possessed of our tools, our models, and our artisans, she has acquired skill almost equal to our own, and established her reputation for the superiority of her mechanical constructions. She is now exporting large quantities of cotton, woollen, and flax machinery to all parts of the world. The following extracts from Briavoine will corroborate these remarks:—

"The construction of machines in Belgium employs upwards of *five thousand* workmen; and in 1815 this branch of trade was almost *nil*. The value of machines made in 1839 may be stated at ten millions of francs. This valuation is certainly under the truth.

"In 1831, the imports of machinery amounted to 46,372 francs; they have increased regularly in every successive year, till in 1838, they amounted to 4,708,237 francs. The exports during the same period have increased from 539,234 francs to 6,136,187 francs.

"The great utility to the country of this branch of trade is very evident. The employment of five thousand workmen at three francs a day, and reckoning three hundred working days per annum, is *four millions four hundred thousand francs*, equal to *one hundred and eighty thousand pounds sterling*.

"The machines which we imported from England—*those which we continue to import* to serve as models, and which will soon cease—cost, with expense of smuggling, carriage, &c., at least *fifty per cent. dearer than those which* we construct ourselves."

(*To be continued.*)

REPORT OF JOHN SMEATON, ESQ., C. E.,

RESPECTING THE ACCOMMODATION FOR STEAM-VESSELS AT SOUTHAMPTON.

"London, 12th September, 1840.

"Sir,—In compliance with your instructions, I have made a survey of the Southampton river, with a view to the accommodation which may be expected for your larger class of steam-vessels, and beg to report as follows:—

"That I consider the situation of the proposed new docks extremely well adapted for any commerce which may be carried on by steam or sailing-vessels; the facilities which the Southampton river affords have been ably and correctly stated by the officers of the navy, in their evidence before a committee of the House of Commons, and the expectations expressed by them in regard to the port of Southampton appear to me to be fully borne out by the construction of the new docks now in progress.

"I have taken the plans and surveys of Mr. Giles in preference to making them myself, and have every confidence that they are executed with his established accuracy.

"The approach to the mouth of the new dock being through the river Itchen, affords the advantage of steamers getting out of the general traffic and entering the basin in quiet water; and although the channel be narrow, it can never be disadvantageous to a steam-vessel, while the current of the ebb tide from so large an estuary would tend to the keeping the deep-water channel clear of deposits of mud and silt.

"A very great advantage to the port consists in the extraordinary period of high water, which may be said to continue stationary for about two hours, thus allowing a facility for the navigation not to be met with in any other harbour in England.

"The freedom from ice in the river Itchen may also be regarded as a great desideratum in steam navigation, as well as the steady and moderate currents of the flood and ebb tides.

"The facility of approach and departure at all times of the tide, and in every season of the year, has been already explained in the reports and the evidence of nautical men; and it appears to me that their opinions are fully warranted.

"Another important consideration with regard to the port of Southampton is the proximity to London created by the railway, and affording, by means of the telegraph now used so successfully on the Blackwall Railway, a communication for Government, or others, not to be met with elsewhere.

"The entrance to the tidal basin now in progress of execution secures a quiet harbour, as it will be sheltered from any heavy sea, and peculiarly protected from the south-west winds which prevail in the south of England.

"Reference having been made to a sand bank a little below the confluence of the rivers Southampton and Itchen, I have examined it, and find that there is fully 18 feet over it at low water of spring tides; and as there is besides a deep navigable channel, there can be no obstruction by the bank to the navigation to and from Southampton.

"The river from Southampton to the sea is considered by the most experienced sailors free from all obstruction, and capable of containing any number of vessels, with very good anchorage.

"The entrance to the Itchen may be made quite marked and distinct by the mooring of a floating light outside of the bank on which the docks are to be placed.

"I have carefully examined the river Itchen with reference to the deepening of the water to 18 feet low water spring tides, as proposed by Mr. Giles, and am of opinion that no difficulty need be apprehended in the execution of the work, or in keeping the depth afterwards. The substance of the soil is light, and easily dredged up by ballast lighters or steam dredge boats, and when once formed, I consider that the ebb tide current will carry off all the deposit from the channel.

"The deposit of mud and silt is very small in the river Itchen, on account of the purity of its supply of spring water; and the estuary is extensive, and allows a reservoir of tide water sufficient to keep clear the entrance to the docks.

"I therefore consider that the situation of the proposed docks at Southampton affords an accommodation for your steam-vessels which cannot be exceeded in England; and as there exists no difficulty in the construction of the tide basin and docks, I consider that when the works are advanced, Southampton, as a steam-boat station, will be unrivalled in England.

"I am, &c.,

"Henry Longlands, Esq. "JOHN SMEATON."

MISCELLANEOUS.

Archimedian Screw Propeller.—The Great Western Steam Company determined some time ago to fit out the *Mammoth*, an iron ship, of 3,200 tons, and upwards of 1,000 horse power, with the screw propeller; being now plated up, and her engines in a forward state, the Directors have chartered the *Archimedes*, to enable them to decide upon the most approved arrangements of machinery, &c. The *Mammoth* is to be put into the trade between Bristol and New York, and the proprietors confidently expect, that she will perform her voyages considerably under the average time required by steam ships at present. The position of the propeller being considerably under the water line, and in the dead wood of the vessel, it will be thus much less exposed to injury from gunshot, floating timber, ice, and other casualties, than the paddle wheels. But the great advantage which a sea-going steamer, fitted up on the propeller principle, will possess over those with paddle-wheels, will consist in her superior facility of steering, and safety in lying to in heavy weather. Her Majesty's government have given immediate instructions for building an iron steamer to be fitted with the propeller. Another vessel, propelled on the same principle, will be shortly at work in Shoreham harbour.

The President of the Institution of Civil Engineers.—On Wednesday evening, the 12th inst., James Walker, Esq., President of the Institution of Civil Engineers, held his annual conversazione at his residence in Great George Street, which was attended by an immense number of noblemen, gentlemen, and the most distinguished characters of the age for talent and genius. Among the guests was the premier, Lord Melbourne, and several members of the administration, as well as of the opposition. If the President's soirée goes on increasing as it has done every year, he will shortly find it necessary to have all the houses on

one side of Great George Street to contain them. The works of art and models of new inventions were numerous and well selected, and afforded much interest to the company assembled.

SMOKE CONSUMERS.—The important desideratum in railway travelling, of using coal instead of the expensive article of coke, has just been attained. The improvement in the combustion of fuel and smoke, for which Mr. Hall obtained a patent in January last, has within the last ten days been tried on the Derby and Nottingham Railway, as applied to the "Wizard" locomotive engine, belonging to the Midland Counties Railway Company. William Hannay, Esq., and Henry Youle, Esq., two of the Directors of the Company, accompanied by Francis Wright, Esq., H. B. Campbell, Esq., and other gentlemen, made a full trial of the invention a few days ago, when it proved highly satisfactory to them, the combustion of the smoke being complete. At the suggestion of Francis Wright, Esq., Mr. Hall's apparatus was then stopped off, when the most dense clouds of smoke issued from the chimney, this contrast rendering the success of the process the more striking. This improvement in locomotive engines is the more valuable, on account of the simplicity of the invention, the trifling expense at which it may be applied, and its not requiring the engines to be taken from their regular duty; the apparatus may be added and taken away at pleasure in a quarter of an hour's time; the engines and boilers require no alteration.—*Hull Advertiser.*

INSTITUTION OF CIVIL ENGINEERS.—At the usual weekly meeting of this institution on Tuesday evening, several interesting papers were read. One from the Hon. Mr. Stewart, on the application of peat to the purpose of building "sea walls," excited considerable interest. The author described some embankments constructed with it on the estates of his brother the Earl of Galway, to reclaim various portions of land, to the amount of many hundred acres, and stated that it had been found to answer extremely well for several reasons, the most prominent of which were, that the blocks of peat, when well rammed down, grew together, thus forming a most complete "puddle" wall; and that from its spongy nature it was not liable to crack in dry weather like clay, when any portion of it was in water, as moisture was in that case drawn up to all parts of it.

CHEVERTON'S ELECTROTYPE BUSTS.—Among the novelties exhibited at the *conversazione* given by Mr. Walker, as President of the Institution of Civil Engineers, was a small electrotype bust, by Mr. Cheverton, the artist in ivory, and reduced by him in the first instance from Chantrey's model, of Dr. Dalton. It is the united result of his peculiar art of mechanical sculpture, and the new art of electrometallurgy. It had all the appearance of having received the highest finish which the best chasing could bestow, and yet we are assured that it had not been touched in the way of improvement since it came out of the mould, which indeed was exhibited at the same time in proof of this assertion, and in illustration of the process adopted. A bust of some destructible material being prepared, a metallic coating is formed over its surface by electro deposition, which, on the removal of the inclosed mass, constitutes the mould for the electro-type bust to be deposited in, and from which it is detached by piecemeal. The preparatory process, by which the destroyed figures are produced, was not disclosed by Mr. Cheverton, but we understand that his facilities for multiplying them are such, that notwithstanding this apparently costly item in the manufacture, the electro-types may be sold at one-half the price of bronzes in general, whilst they will possess the beauty and fidelity for which his ivory copies of works of art are known to the public.—*Mech. Mag.*

GALLOWAY'S RAILWAY SYSTEM.—Some experiments have been lately made at the Adelaide Gallery, on the railway system proposed by Mr. Elijah Galloway, of which the following is a description. The rails do not differ in any respect from those now in use; the side carriage-wheels are also the same as in common use, but there are two other wheels under the centre of the carriage, and exactly in a line between the side-wheels; these centre wheels are 1-7th less in diameter than the side wheels; the centre wheels traverse on a wood centre rail, which is in 12 feet lengths, but perfectly continuous. The force that is employed for moving the moveable rail, proceeds from the stationary engine as above mentioned. They draw the rail in the direction towards which the engine is required to move, and as the rail moves 7-8ths of a mile, the carriage completes the distance of one mile; this being the difference between the periphery of the interior and exterior wheels.

RAILWAY TRAIN CONTROLLER.—We have witnessed at the zinc works in Parliament-street, the working of a model, on a tolerable scale, of a simple and ingenious invention of Mr. Walter Hancock, the well known steam carriage engineer. It consists of two long plates of iron connected by a hinge worked by an upright lever, and placed by the side of the rail, at an elevation above of from four to twenty inches. The hinge is moveable backwards and forwards, and when employed to stop an approaching train is brought near the rail, when the inclined plates thus come in contact with arms projecting from the engine and carriages, which start the whistle, shut off the steam, and bring the breaks into successive action as they pass, without subjecting the engine to any injuries by sudden strain. The contrivance is extremely simple, and will well repay the trouble of inspection by those of our readers who take an interest in the subject. Mr. Hancock well observes, that as the control of the engine is at present solely in the hands of the engine driver, if any accident happens to him the train gets away, and the lives of all the passengers are placed in serious danger, and unless the power of the engine be exhausted, or it be stopped by some serious obstacle, it flies past the next station in despite of all the efforts of the persons in attendance. By means of this contrivance, however, any policeman or other attendant can stop a train at his station with as little trouble as he turns the switches. Mr. Hancock proposes to place the controller at quarter or half-mile distances on the lines, but particularly at a proper distance from the stations, to guard against furiously driving into them or overrunning them.

STEAM NAVIGATION.—The *Sir William Wallace*, a steam-vessel of 100 horse power, built by Mr. Stephen Wood, of the South Shore, Gateshead, and fitted up with two engines by Messrs. Hawks, Stanley, and Co., lately made an experimental marine trip. The engines were manufactured under the superintendence of Mr. John Golightly, Messrs. Hawkes and Co.'s engineer; and the paddle-wheels, and steam and exhausting "ways," being on a new construction, some details may be of interest and importance to mechanical men. The improvement on the common steam slides, consists in the steam being admitted into the cylinder by two plain or simple brass plates, connected together by a rod: one plate to admit steam at the top of the cylinder—the other to admit steam at the bottom—and so contrived, that, by means of two eccentrics, the steam port or way can be worked fully open, or shut at any point to the extent of two thirds, and the steam worked expansively. This change of steam port can be instantaneously effected, without stopping the engine. The steam ports have no other duty to perform, the exhaustion and condensation being effected by two double mitre valves, which always work fully open, whether the steam ports are or are not so. Thus a full condensation is always in operation. This arrangement also renders the working of the hand-gear comparatively very easy, there being nothing to contend with but the pressure of the steam on the area of the steam ports, and the vacuum on the double mitre valves. The paddle-wheels, to which we next turn our attention, are 15 feet in diameter, with 24 floats on each wheel—12 on the inside, and 12 on the outside; for the wheel may be described as double, having three rims—the middle rim having 24, and the inner and outer rim each 12 arms, to receive the ends of the inner and outer floats. First an inner, and then an outer float, falls into the water, and is immersed 4 inches below the surface. Each float is five feet long by 2 broad, thus giving a surface of 480 feet on the two wheels. The improvements which we have described, greatly diminish the vibration in the boat and engines—lessen the swell and back-water from the paddle-wheels—and make the vessel go with more steadiness and regularity.—*Gateshead Observer.*

AUSTRALIAN MINERALS.—One of the most valuable acquisitions to the public treasury that have yet been unveiled since the first formation of the colony, is the developement of a new source of internal wealth, in the discovery of a rich ore of metal, about twenty miles in the interior, by two gentlemen on an exploratory excursion. It exists in immense quantities, there being thousands of tons already visible in a mountainous fissure. Specimens of the above have been brought to town for scientific investigation, and have since been subjected by an operative chemist to all the available analysis of the colony (scanty as it is). The following are its natural characters, with the chemical results:—Its native appearance is of a grey blue colour, in small crystals about the size of gunpowder; inodorous, incombustible, insoluble in the strongest mineral acids or alkalies; specific gravity, 11,739. On being examined through the microscope, the crystals are presented in an octagonal form; on being subjected to the strong red heat of the blow pipe, small ignited globules fuze out with difficulty, and instantly coalesce into a button; on cooling, it presents itself as a soft laminable metal, hardening but little under the hammer, very flexible, not very ductile, slightly tenacious, fusible at about 610 deg. Fahrenheit, thereby clearly demonstrating, on considering the specific gravity, that the great bulk of the mineral is lead, existing as a sulphuretted oxide, and in an alloy with some other metal or metals, possibly unknown either in the old or new world. It must, however, be understood, that, from want of the necessary reagents used in chemical manipulations, it is impossible to arrive at any correct analysis.—*Port Philip Patriot.*

A LONG YARN.—On Tuesday last, a new 14-inch capstan rope, of the extraordinary length of 340 fathoms, without being at all spliced, was completed by Mr. Hawke, of Scorrier, for Tresavean mine. This, we believe, is the longest capstan rope ever manufactured in one length, and weighs nearly seven tons.—*Falmouth Packet.*

LANGUIN COLLIERIES.—We are informed that several valuable veins of coal, of the finest quality, have just been won under the direction of M. Nixon, at the colliery of Languin, near Nantes, belonging to the Languin Iron and Coal Company, which was formed last year by Mr. Lamie Murray, of London. The coal is said to be admirably suited for making cast iron of superior quality, to which use it is to be exclusively devoted by the proprietors, abundance of the richest ore being found in the immediate neighbourhood. The small quantity of coke-made iron produced in France, and its very high price as compared with English iron, renders the success of the undertaking of national importance to this country.—*Galignani's Messenger.*

RAILWAY TO SALISBURY.—It is confidently reported that the proprietors of the South Western Railway have taken up the subject of a railway to Salisbury, from a conviction of the necessity of so doing, to protect their own interests against the Great Western line. We understand that it has been resolved to form a branch from Salisbury to join the branch here between Southampton and Winchester, at Bishopstoke; and thus form a direct railway communication between these three important towns, and also between Salisbury and the metropolis. The share list is said to be already filled, without any assistance from Salisbury.—*Hants Independent.*

HAERLEM AND ROTTERDAM RAILWAY.—The Handelsblad tells us that the works on the iron railroad from Haerlem to Rotterdam, the whole of which between the two towns is already marked out, will be commenced very shortly, beginning at Rotterdam.

THE STOCKPORT VIADUCT.—The Stockport Viaduct has just been completed. The Manchester and Birmingham direct line of railway now runs over, not through, the town of Stockport. The arches literally stride over that large town.—*Derby Mercury.*

RUSSIAN RAILWAY.—It is stated "on good authority," that the Emperor has given his consent to the making of an iron railway between St. Petersburgh and Moscow, which has been projected for some years. It is to be executed by a Joint Stock Company, which has many offers from foreign countries of persons willing to take part in it. In this case it may very probably be commenced this summer. The late Chevalier Gerstner had made the preliminary survey of the line.

HUNGARIAN RAILWAY.—Proposals are made in the *Augsburg Gazette* for a railroad to connect Fiume, Trieste, and the Adriatic ports, with the Hungarian rivers, the Save and the Kulpa, at Sipeck and at Carlstadt. The importation of corn from Odessa and Trieste is considerable. With very little expense, by connecting the Adriatic with the Hungarian rivers, Hungary might furnish the supply that South Russia now does.

GREAT WESTERN RAILWAY.—This magnificent line is rapidly approaching completion. On the 31st it is expected to be extended to Chippenham, 95 miles from London, leaving a gap of only 10 miles to Bath, which will be open in July, and the line completed.

LIST OF PATENTS,

Continued from page 96.

(SIX MONTHS FOR ENROLMENT.)

James Sims, of Redruth, Cornwall, engineer, for "certain improvements in steam engines."—Sealed April 29.

Alfred Jeffery, of Prospect Place, New Hampton, Middlesex, gent., for "a new method of defending the sheathing of ships, and of protecting their sides and bottoms."—Sealed April 29.

George Townshend, of Sapcoll Fields, Leicester, esq., for "improvements in machinery or apparatus for cutting certain vegetable substances."—Sealed April 29.

Joseph Gibbs, of Kennington, civil engineer, for "a new combination of materials for making bricks, tiles, pottery, and other useful articles, and a machine or machinery for making the same, and also a new mode or process of burning the same, which machine or machinery and mode or process of burning, are also applicable to the making and burning of other descriptions of bricks, tiles, and pottery."—Sealed April 29.

Miles Berry, of Chancery Lane, patent agent, for "certain improvements in machinery or apparatus for making or manufacturing nails and brads," being a communication.—Sealed May 4.

Francis Joseph Massey, of Chadwell Street, Middleton Square, watch manufacturer, for "improvements in the method of winding up watches and other time keepers."—Sealed May 4.

Edward Newton, of Leicester, manufacturer, and Thomas Archbold, of the same place, machinist, for "improvements in producing ornamental or tambour work in the manufacture of gloves."—Sealed May 4.

Charles Thomas Holcombe, of Bank Side, Borough, merchant, for "certain lubricating or preserving matters for wheels and axles, applicable also to the bearings, journals, or other parts of machinery."—Sealed May 6.

Hugh Graham, of Bridport Place, Hoxton, artisan, for "an improved manufacture of that kind of carpeting usually denominated Kidderminster carpeting."—Sealed May 6.

Moses Poole, of Lincoln's Inn, esq., for "improvements in the manufacture of fabrics by felting," being a communication.—Sealed May 6.

Philemon Augustine Morley, of Birmingham, manufacturer, for "certain improvements in the manufacture of sugar moulds, dish covers, and other articles of similar manufacture."—Sealed May 6.

James Hancock, of Sidney Square, Mile End, civil engineer, for "certain improvements in the manufacture of locks, keys, latches, and other fastenings, part of which improvements are applicable to taps and cocks for drawing off fluids."—Sealed May 6.

John Paley, jun., of Ryston, Lancaster, manufacturer for "certain improvements in looms for weaving."—Sealed May 10.

Hooton Deverill, of Nottingham, lace manufacturer, for "certain improvements in machinery, for making and ornamenting lace, commonly called bobbin-net lace."—Sealed May 10.

Andrew M'Nab, of Paisley, North Britain, engineer, for "certain improvements in the manufacture of bricks."—Sealed May 11.

Edward Taylor, of King William Street, London, gent., for "certain improvements in the construction of carriages used on railroads," being a communication.—Sealed May 11.

Henry Pinkers, of Maddox Street, Saint George, Hanover Square, for "an improved method or methods of applying electrical currents to electricity, either frictional, atmospheric, voltaic, or electro magnetic."—Sealed May 14.

James Gregory, coal master, and William Green Tinner, both of West Bromwich, Stafford, for "certain improvements in the manufacture of iron and steel."—Sealed May 14.

Pierre Journet, of Dean Street, Soho, engineer, for "improvements in fire escapes, which improvements are applicable to other useful purposes."—Sealed May 19.

John Carr, jun., of Paddington, engineer, for "improvements in apparatus for retarding and stopping railway carriages."—Sealed May 20.

Charles Phillips, of Chipping Norton, Oxford, engineer, for "improvements in reaping and cutting vegetable substances as food for cattle."—Sealed May 20.

Joseph Woods, of Lawn Place, Lambeth, civil engineer, for "certain improvements in locomotive engines, and also certain improvements in machinery, for the production of rotatory motion for obtaining mechanical power, which improvements in machinery are also applicable for raising or impelling fluids."—Sealed May 22.

William Gall, of Beresford Terrace, Surrey, for "an invention of certain improvements in the construction of inkstands," being a communication.—Sealed May 22.

John Ainslie, farmer, Redheugh, North Britain, for "a new and improved mode of making or moulding tiles, bricks, retorts, and such like work, from clay and other plastic substances."—Sealed May 22.

Christopher Dumont, of Mark Lane, London, for "improvements in the manufacture of metallic letters, figures, and other devices," being a communication.—Sealed May 22.

John Winterborn, of Clarence Place, Hackney Road, surgeon, for "improvements in machinery to facilitate the removal of persons and property from premises in case of fire, which improvements are applicable to raising and lowering weights generally, to assist servants cleaning windows, and as a substitute for scaffolding."—Sealed May 22.

William Lewis Rham, of Winkfield, Berks, clerk, "for certain improvements in machinery or apparatus for preparing land, and sowing or depositing grain, seeds, and manure."—Sealed May 25.

John Whitehouse, of Deptford, engineer, for "an improved method of making boilers to be used in marine steam engines."—Sealed May 25.

William Joest, of Ludgate-hill, merchant, for "improvements in propelling vessels," being a communication.—Sealed May 26.

George Hulme, of Saint John Street, West Smithfield, brass and cock founder, for "improvements in water closets."—Sealed May 27.

James Shanks, of Saint Helens, Lancashire, chemist, for "improvements in the manufacture of carbonate of soda."—Sealed May 27.

Joseph Bettridge, of Birminghan, wood turner, for "an improved method of manufacturing papier maché, pearl, china, ivory, horn, wood, and compositions, into pillars and stands, for table and other lamps, and other articles of domestic furniture."—Sealed May 27.